US009344214B2

(12) **United States Patent**
Wakabayashi

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(45) **Date of Patent: May 17, 2016**

(54) **OPTICAL WAVELENGTH PATH REARRANGING METHOD, COMPUTER PRODUCT, OPTICAL TRANSMISSION MANAGING APPARATUS, AND OPTICAL TRANSMISSION APPARATUS**

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(72) Inventor: **Jun Wakabayashi**, Kawasaki (JP)

(73) Assignee: **FUJITSU LIMITED**, Kawasaki (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 103 days.

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(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**
H04J 14/02 (2006.01)

(52) **U.S. Cl.**
CPC ***H04J 14/0257*** (2013.01); *H04J 14/0227* (2013.01); *H04J 14/0238* (2013.01); *H04J 14/0254* (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

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* cited by examiner

Primary Examiner — Darren E Wolf
(74) *Attorney, Agent, or Firm* — Fujitsu Patent Center

(57) **ABSTRACT**

An optical wavelength path rearranging method includes detecting time that elapses since a setting of optical wavelength paths in an optical wavelength division multiplexing network; and moving to a predetermined long-period optical wavelength range, an optical wavelength path that is among the optical wavelength paths and for which the detected elapsed time is long, where the optical wavelength path rearranging method is executed by a processor.

5 Claims, 39 Drawing Sheets

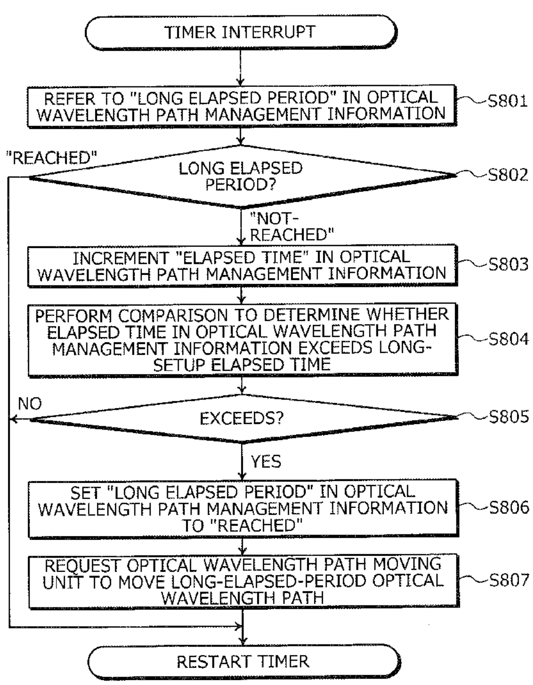


FIG.1

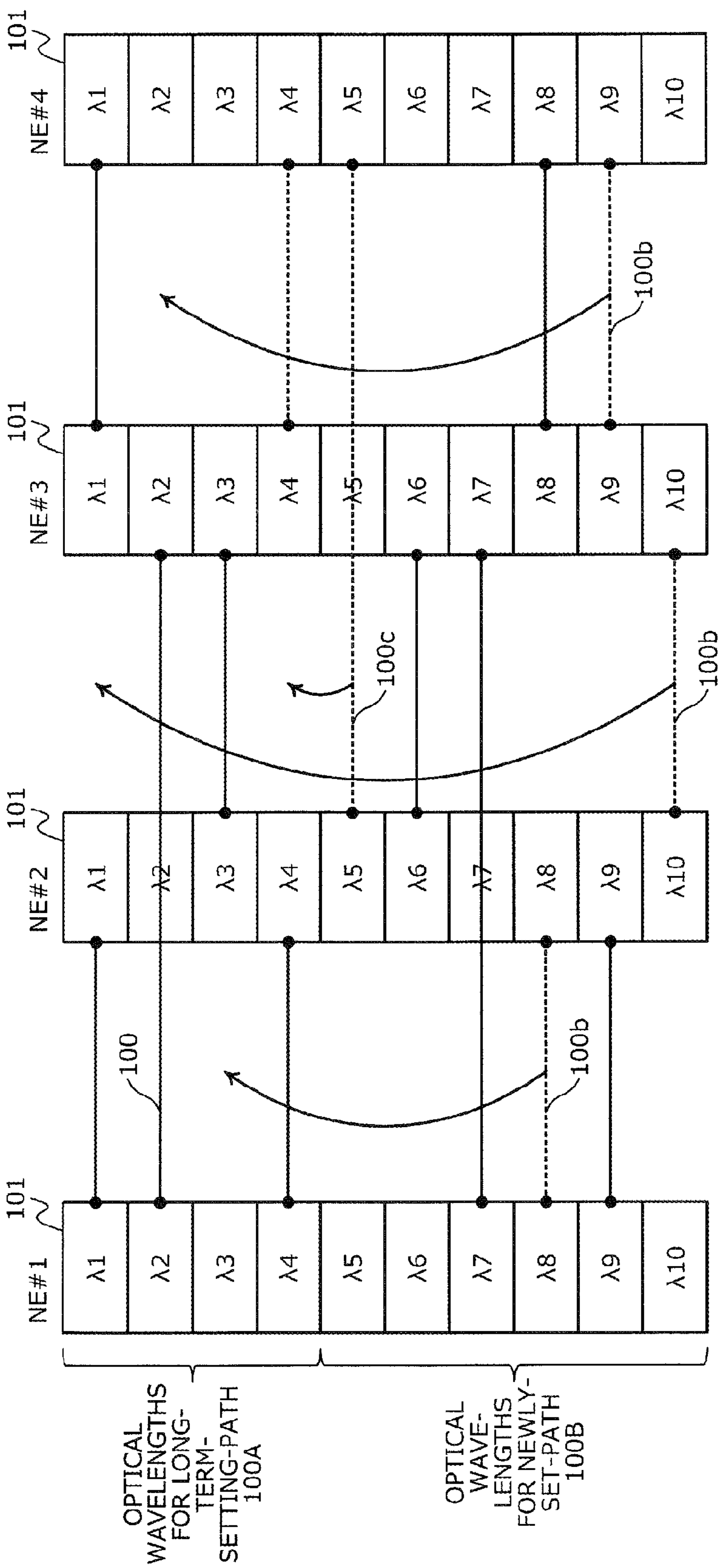

NE#1
NE#2
NE#3
NE#4
101
λ1
λ2
λ3
λ4
λ5
λ6
λ7
λ8
λ9
λ10
100
100b
100c
OPTICAL WAVELENGTHS FOR LONG-TERM-SETTING-PATH 100A
OPTICAL WAVE-LENGTHS FOR NEWLY-SET-PATH 100B

FIG.2

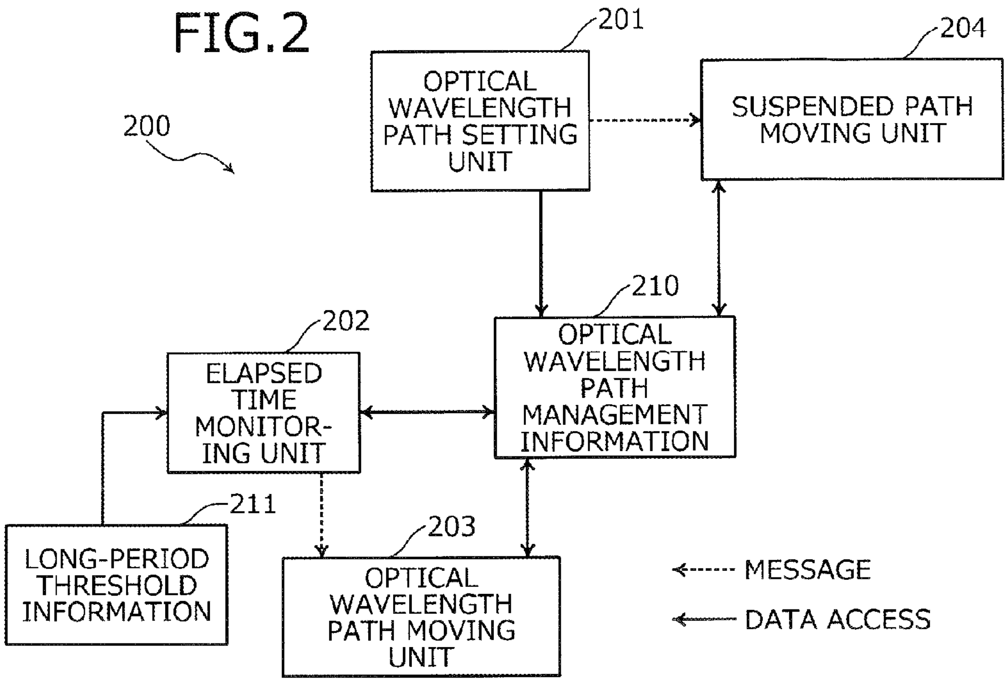


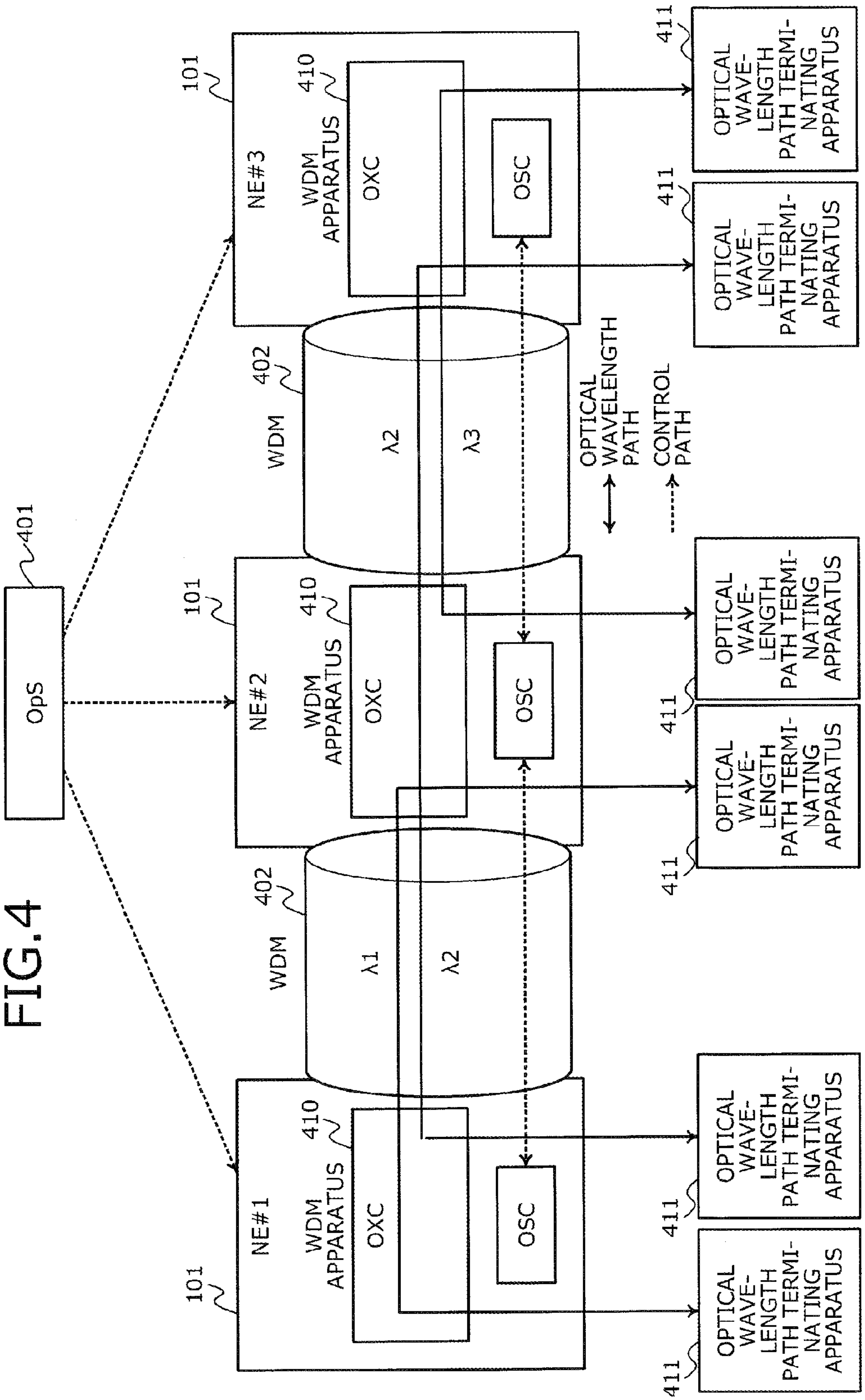
FIG.3

210

OPTICAL WAVE-LENGTH PATH ID	OPTICAL WAVELENGTH PATH ROUTE INFORMATION	ELAPSED TIME	LONG ELAPSED PERIOD	WAITING FOR VACANCY
1	*1	24	REACHED	NONE
2	*1	15	REACHED	NONE
3	*1	3	NOT-REACHED	NONE
...	...	...	...	...
n-1	*1	31	REACHED	SUSPENDED
n	*1	5	NOT-REACHED	NONE

*1: NECESSARY INFORMATION DIFFERS FOR OpS AND NE

FIG.4



401
OpS
101
NE#1
NE#2
NE#3
WDM APPARATUS
410
OXC
OSC
402
WDM
λ1
λ2
λ3
OPTICAL WAVELENGTH PATH
CONTROL PATH
411
OPTICAL WAVE-LENGTH PATH TERMI-NATING APPARATUS

FIG.5

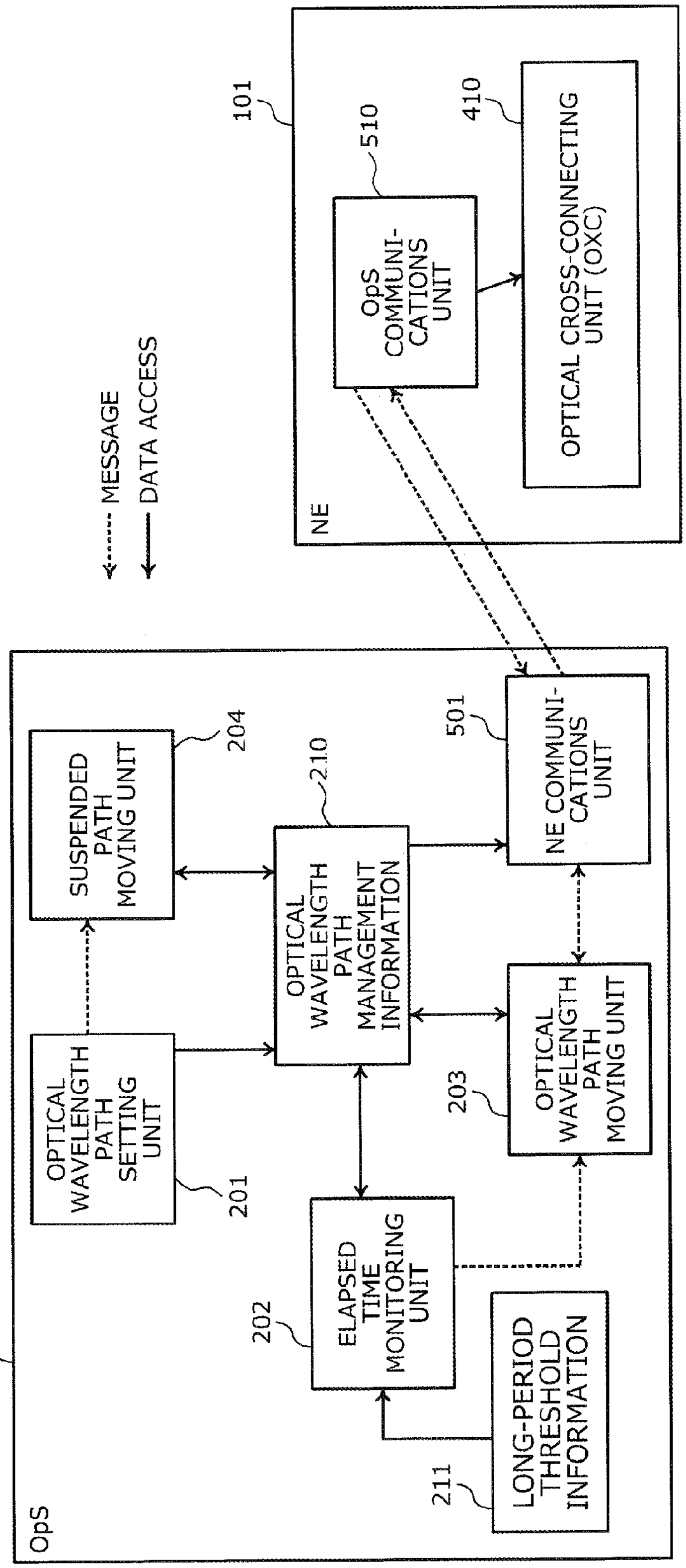
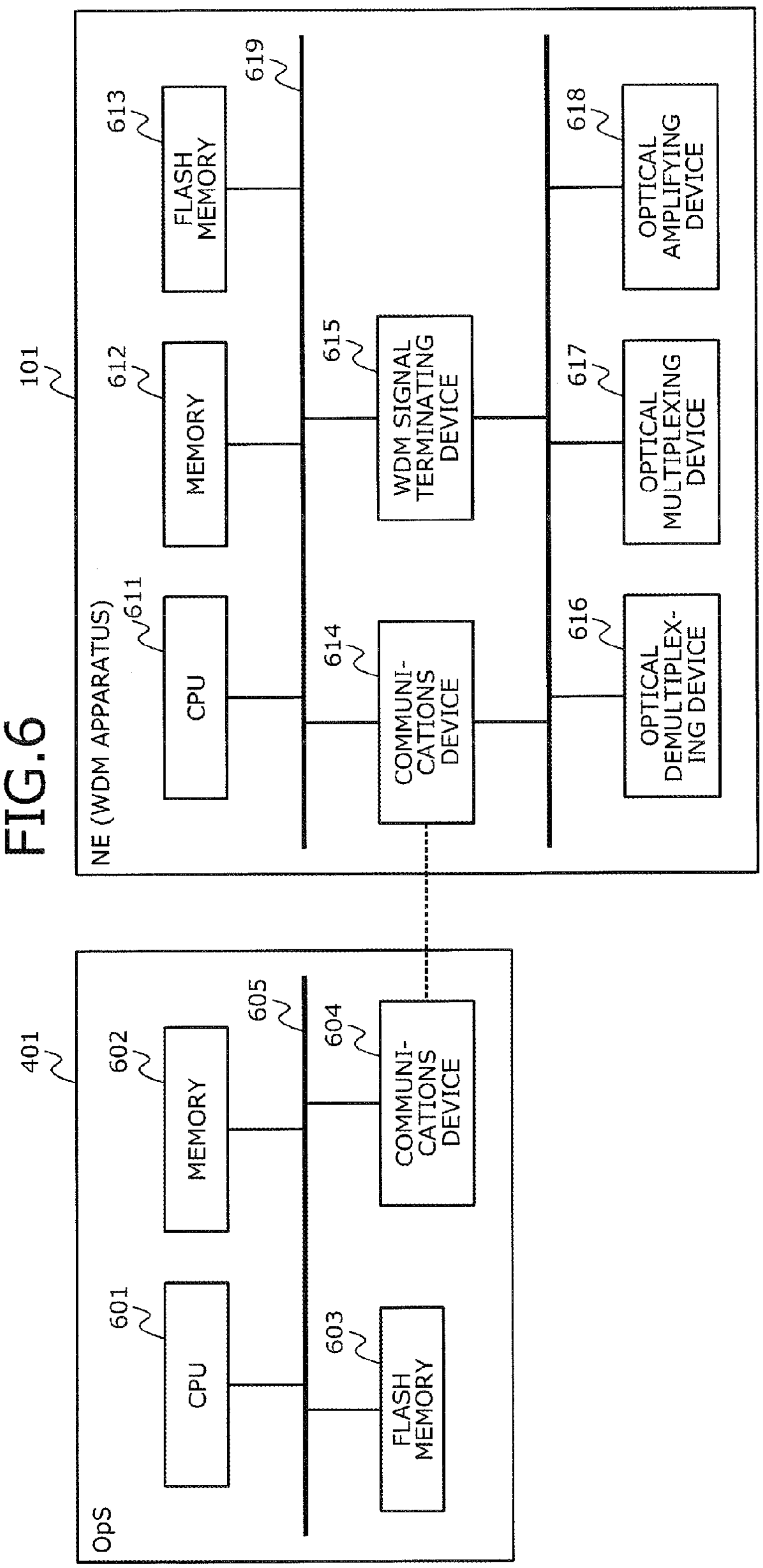

MESSAGE
DATA ACCESS
NE
101
510
OpS COMMUNI-CATIONS UNIT
410
OPTICAL CROSS-CONNECTING UNIT (OXC)
OpS
401
OPTICAL WAVELENGTH PATH SETTING UNIT
201
SUSPENDED PATH MOVING UNIT
204
OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION
210
NE COMMUNI-CATIONS UNIT
501
ELAPSED TIME MONITORING UNIT
202
OPTICAL WAVELENGTH PATH MOVING UNIT
203
LONG-PERIOD THRESHOLD INFORMATION
211

FIG.6



101
NE (WDM APPARATUS)
CPU
611
MEMORY
612
FLASH MEMORY
613
619
COMMUNI-CATIONS DEVICE
614
WDM SIGNAL TERMINATING DEVICE
615
OPTICAL DEMULTIPLEX-ING DEVICE
616
OPTICAL MULTIPLEXING DEVICE
617
OPTICAL AMPLIFYING DEVICE
618
401
OpS
CPU
601
MEMORY
602
FLASH MEMORY
603
COMMUNI-CATIONS DEVICE
604
605

FIG.7

701

MOVEMENT CONTROL MESSAGE

MESSAGE TYPE	RESPONSE TYPE	MOVEMENT OBJECT DIREC-TIONAL PATH	MOVEMENT SOURCE OPTICAL WAVE-LENGTH	MOVEMENT DESTINA-TION OPTICAL WAVE-LENGTH

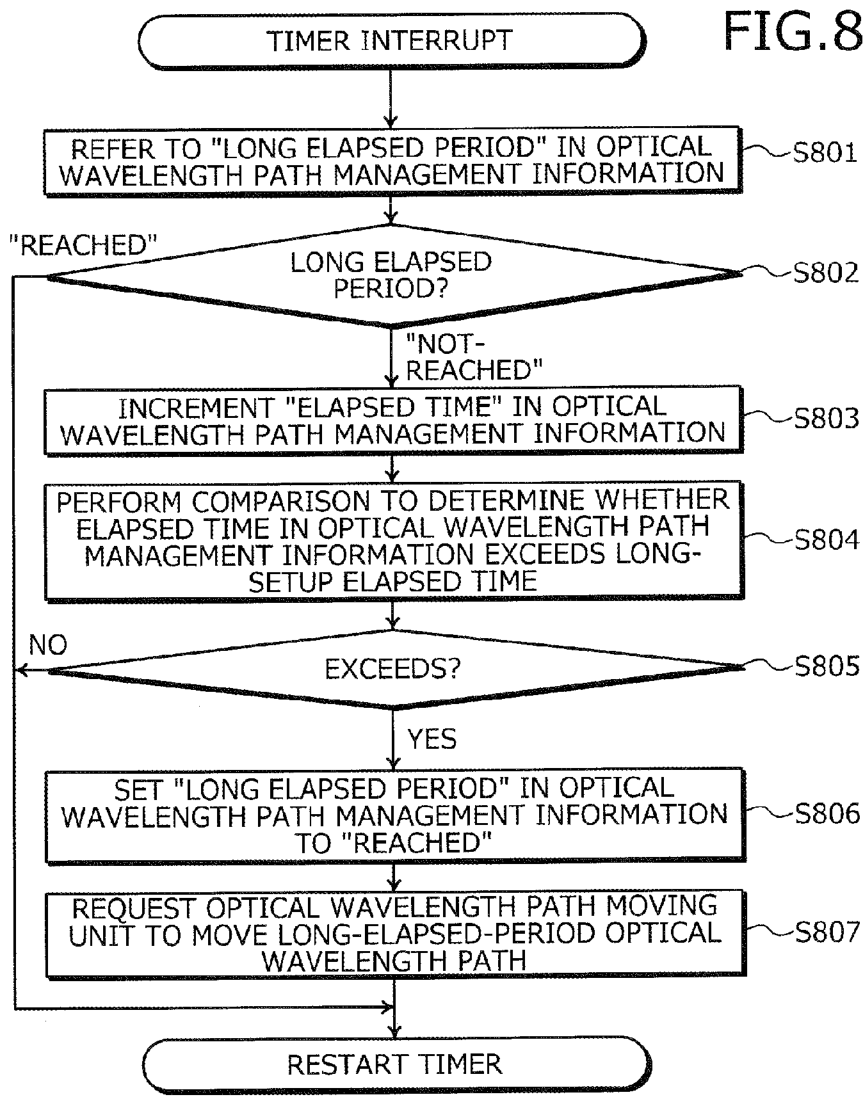


FIG.8

FIG.9

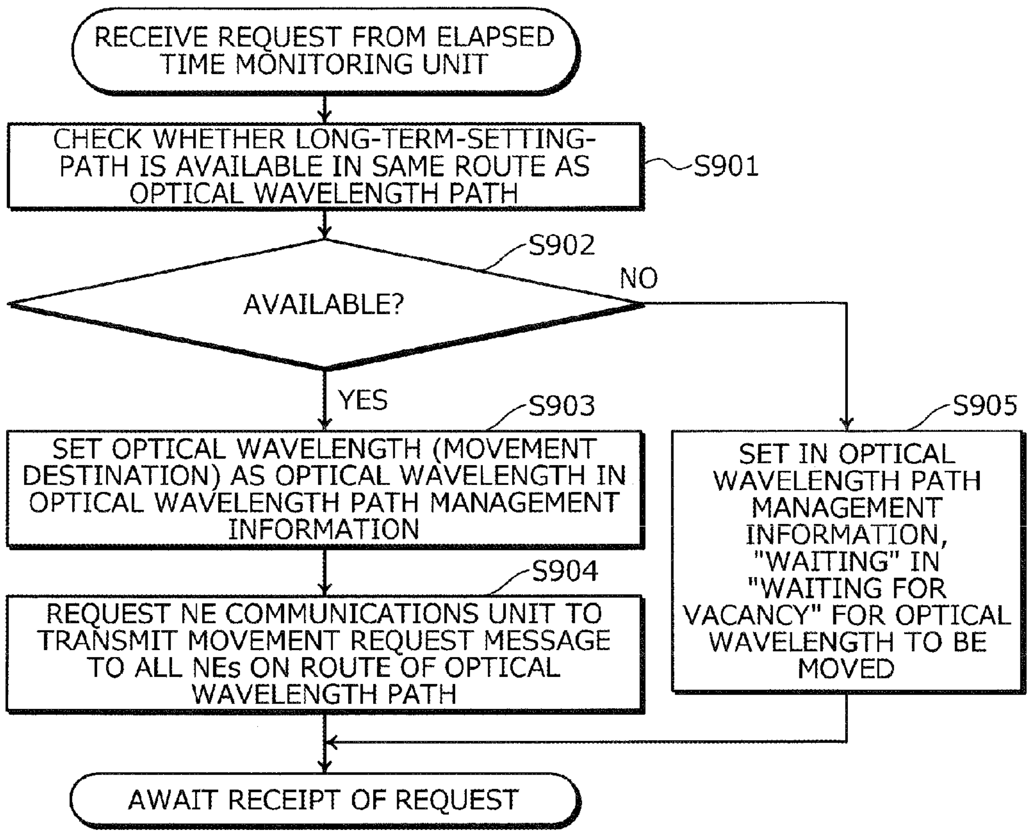

RECEIVE REQUEST FROM ELAPSED TIME MONITORING UNIT
CHECK WHETHER LONG-TERM-SETTING-PATH IS AVAILABLE IN SAME ROUTE AS OPTICAL WAVELENGTH PATH
S901
S902
AVAILABLE?
NO
YES
S903
SET OPTICAL WAVELENGTH (MOVEMENT DESTINATION) AS OPTICAL WAVELENGTH IN OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION
S904
REQUEST NE COMMUNICATIONS UNIT TO TRANSMIT MOVEMENT REQUEST MESSAGE TO ALL NEs ON ROUTE OF OPTICAL WAVELENGTH PATH
S905
SET IN OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION, "WAITING" IN "WAITING FOR VACANCY" FOR OPTICAL WAVELENGTH TO BE MOVED
AWAIT RECEIPT OF REQUEST

FIG.10

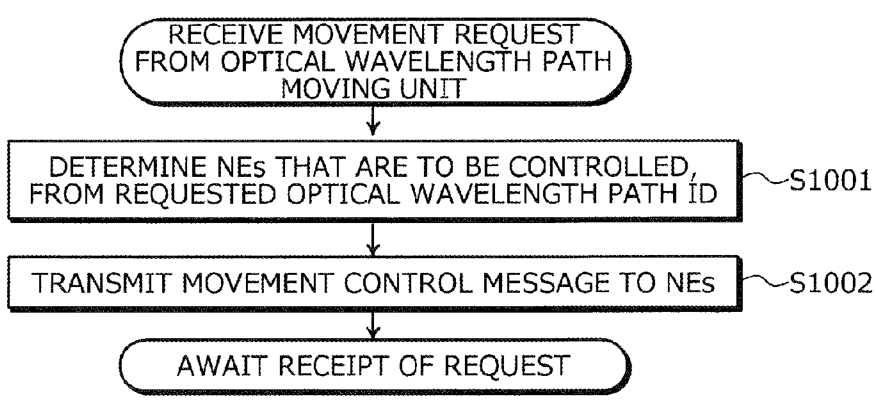

RECEIVE MOVEMENT REQUEST FROM OPTICAL WAVELENGTH PATH MOVING UNIT
DETERMINE NEs THAT ARE TO BE CONTROLLED, FROM REQUESTED OPTICAL WAVELENGTH PATH ID
S1001
TRANSMIT MOVEMENT CONTROL MESSAGE TO NEs
S1002
AWAIT RECEIPT OF REQUEST

FIG.11

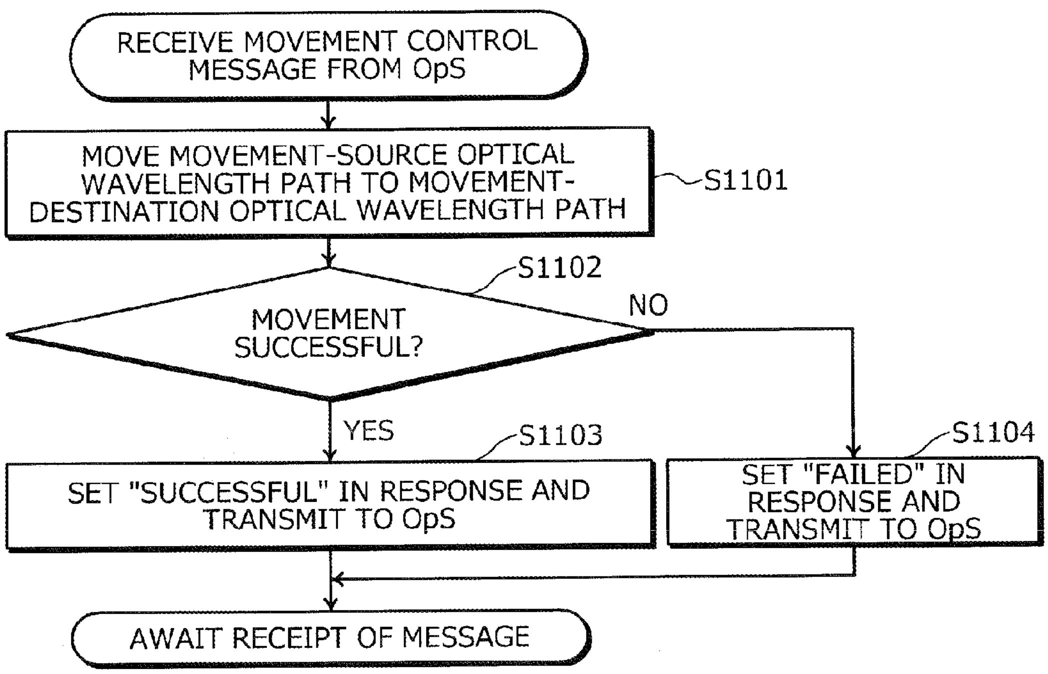

RECEIVE MOVEMENT CONTROL MESSAGE FROM OpS
MOVE MOVEMENT-SOURCE OPTICAL WAVELENGTH PATH TO MOVEMENT-DESTINATION OPTICAL WAVELENGTH PATH
S1101
S1102
MOVEMENT SUCCESSFUL?
NO
YES
S1103
SET "SUCCESSFUL" IN RESPONSE AND TRANSMIT TO OpS
S1104
SET "FAILED" IN RESPONSE AND TRANSMIT TO OpS
AWAIT RECEIPT OF MESSAGE

FIG.12

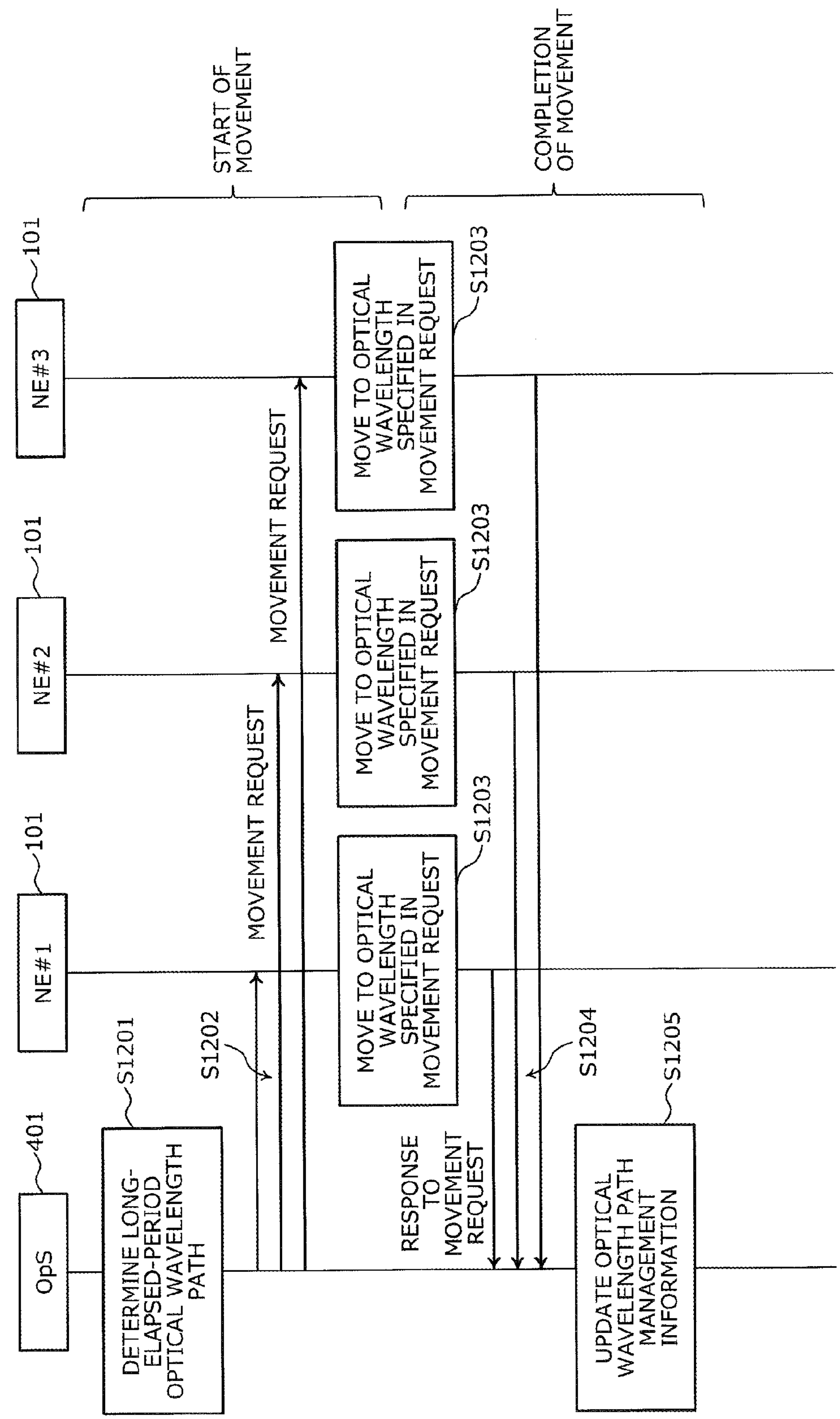
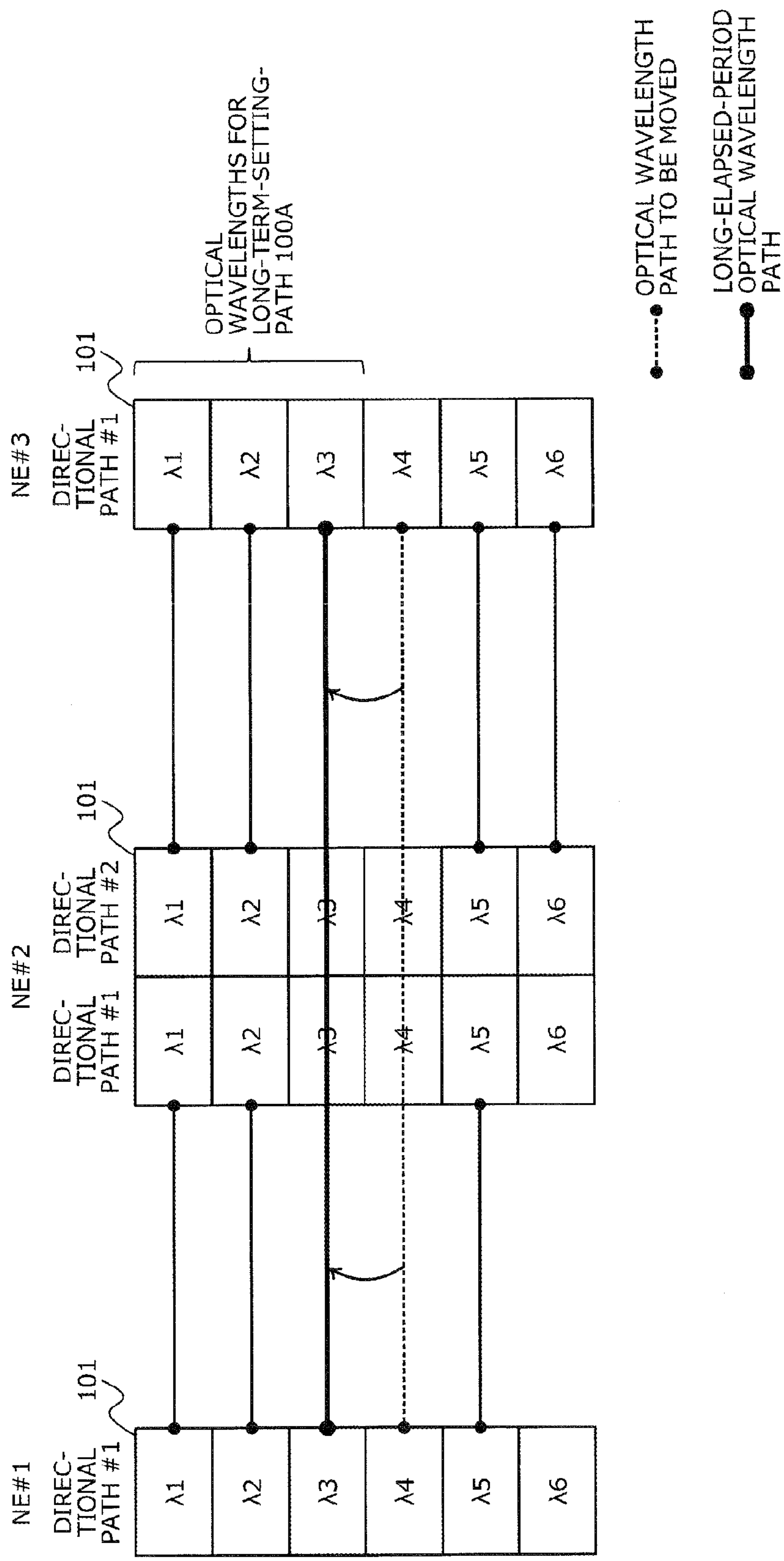

401
OpS
101
NE#1
101
NE#2
101
NE#3
START OF MOVEMENT
COMPLETION OF MOVEMENT
S1201
DETERMINE LONG-ELAPSED-PERIOD OPTICAL WAVELENGTH PATH
S1202
MOVEMENT REQUEST
MOVEMENT REQUEST
MOVEMENT REQUEST
S1203
MOVE TO OPTICAL WAVELENGTH SPECIFIED IN MOVEMENT REQUEST
S1203
MOVE TO OPTICAL WAVELENGTH SPECIFIED IN MOVEMENT REQUEST
S1203
MOVE TO OPTICAL WAVELENGTH SPECIFIED IN MOVEMENT REQUEST
S1204
RESPONSE TO MOVEMENT REQUEST
S1205
UPDATE OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION

FIG.13



NE#1
DIREC-
TIONAL
PATH #1
101
λ1
λ2
λ3
λ4
λ5
λ6
NE#2
DIREC-
TIONAL
PATH #1
DIREC-
TIONAL
PATH #2
101
NE#3
DIREC-
TIONAL
PATH #1
101
OPTICAL
WAVELENGTHS FOR
LONG-TERM-SETTING-
PATH 100A
OPTICAL WAVELENGTH
PATH TO BE MOVED
LONG-ELAPSED-PERIOD
OPTICAL WAVELENGTH
PATH

FIG.14A

AT START OF MOVEMENT FOR OPTIMIZATION

OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION 1401 210 1402

OPTICAL PATH ID	WAVELENGTH	Add NODE ID	Thru NODE ID (1)	Thru NODE ID (2)	...	Thru NODE ID (n)	Drop NODE ID	ELAPSED TIME	LONG ELAPSED PERIOD	WAITING FOR VACANCY
1	λ4	1	2	-		-	3	10	REACHED	NONE
2	λ1	2	-	-		-	3	9	NOT-REACHED	NONE
3	λ1	1	-	-		-	2	8	NOT-REACHED	NONE
4	λ5	1	-	-		-	2	3	NOT-REACHED	NONE
5	λ5	2	-	-		-	3	3	NOT-REACHED	NONE
6	λ2	1	-	-		-	2	2	NOT-REACHED	NONE
7	λ2	2	-	-		-	3	2	NOT-REACHED	NONE
8	λ6	2	-	-		-	3	2	NOT-REACHED	NONE
9	-	-	-	-		-	-	-	-	-

FIG.14B

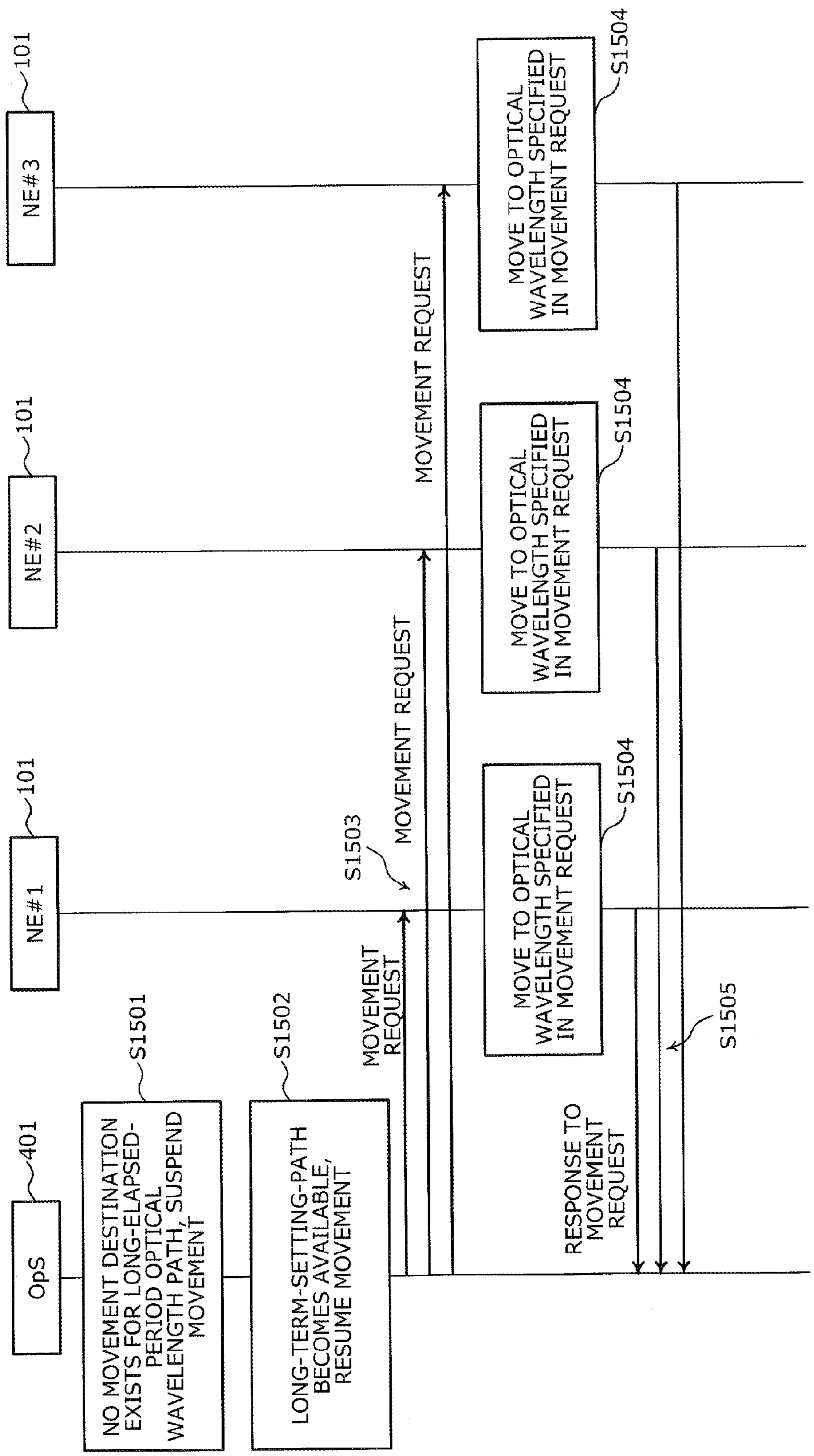
AT COMPLETION OF MOVEMENT FOR OPTIMIZATION

OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION 210

OPTICAL PATH ID	WAVELENGTH	Add NODE ID	Thru NODE ID (1)	Thru NODE ID (2)	...	Thru NODE ID (n)	Drop NODE ID	ELAPSED TIME	LONG ELAPSED PERIOD	WAITING FOR VACANCY
1	λ3	1	2	-		-	3	10	REACHED	NONE
2	λ1	2	-	-		-	3	9	NOT-REACHED	NONE
3	λ1	1	-	-		-	2	8	NOT-REACHED	NONE
4	λ5	1	-	-		-	2	3	NOT-REACHED	NONE
5	λ5	2	-	-		-	3	3	NOT-REACHED	NONE
6	λ2	1	-	-		-	2	2	NOT-REACHED	NONE
7	λ2	2	-	-		-	3	2	NOT-REACHED	NONE
8	λ6	2	-	-		-	3	2	NOT-REACHED	NONE
9	-	-	-	-		-	-	-	-	-

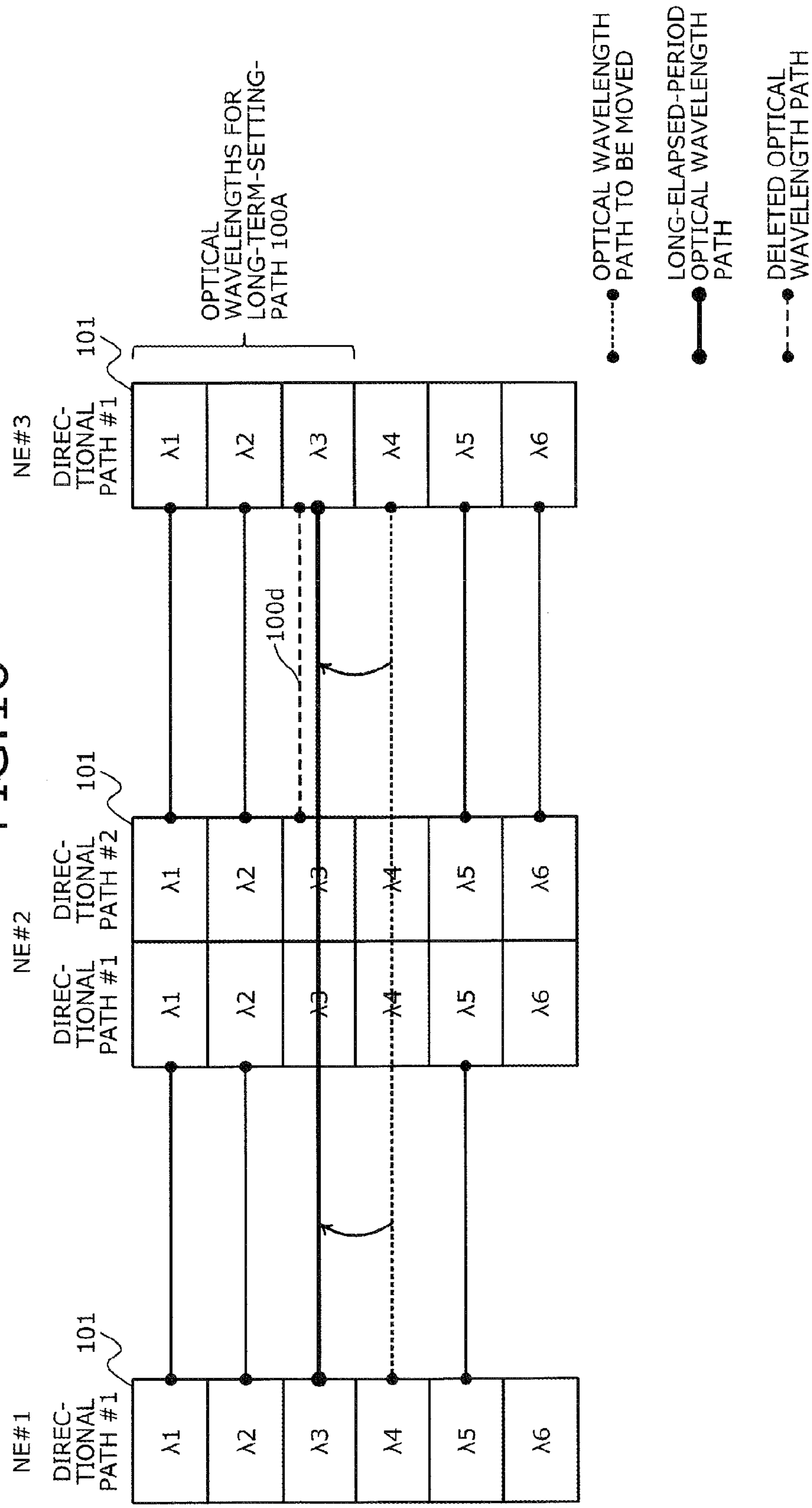
1403

FIG.15



OpS
401
NE#1
101
NE#2
101
NE#3
101
NO MOVEMENT DESTINATION EXISTS FOR LONG-ELAPSED-PERIOD OPTICAL WAVELENGTH PATH, SUSPEND MOVEMENT
S1501
LONG-TERM-SETTING-PATH BECOMES AVAILABLE, RESUME MOVEMENT
S1502
MOVEMENT REQUEST
S1503
MOVEMENT REQUEST
MOVEMENT REQUEST
MOVE TO OPTICAL WAVELENGTH SPECIFIED IN MOVEMENT REQUEST
S1504
MOVE TO OPTICAL WAVELENGTH SPECIFIED IN MOVEMENT REQUEST
S1504
MOVE TO OPTICAL WAVELENGTH SPECIFIED IN MOVEMENT REQUEST
S1504
RESPONSE TO MOVEMENT REQUEST
S1505

FIG.16



NE#1
DIREC-TIONAL PATH #1
NE#2
DIREC-TIONAL PATH #1
DIREC-TIONAL PATH #2
NE#3
DIREC-TIONAL PATH #1
λ1
λ2
λ3
λ4
λ5
λ6
101
100d
OPTICAL WAVELENGTHS FOR LONG-TERM-SETTING-PATH 100A
OPTICAL WAVELENGTH PATH TO BE MOVED
LONG-ELAPSED-PERIOD OPTICAL WAVELENGTH PATH
DELETED OPTICAL WAVELENGTH PATH

FIG.17A

AT START OF SUSPENSION OF MOVEMENT

OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION 1701 1702 1703 210

OPTI-CAL PATH ID	WAVE-LENGTH	Add NODE ID	Thru NODE ID (1)	Thru NODE ID (2)	...	Thru NODE ID (n)	Drop NODE ID	ELAPSED TIME	LONG ELAPSED PERIOD	WAITING FOR VACANCY
1	λ4	1	2	-		-	3	10	REACHED	WAITING
2	λ1	2	-	-		-	3	9	NOT-REACHED	NONE
3	λ1	1	-	-		-	2	8	NOT-REACHED	NONE
4	λ5	1	-	-		-	2	3	NOT-REACHED	NONE
5	λ3	2	-	-		-	3	3	NOT-REACHED	NONE
6	λ2	1	-	-		-	2	2	NOT-REACHED	NONE
7	λ2	2	-	-		-	3	2	NOT-REACHED	NONE
8	λ6	2	-	-		-	3	2	NOT-REACHED	NONE
9	-	-	-	-		-	-	-	-	-

FIG.17B

AT CANCELATION OF SUSPENSION

OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION 210

OPTI-CAL PATH ID	WAVE-LENGTH	Add NODE ID	Thru NODE ID (1)	Thru NODE ID (2)	...	Thru NODE ID (n)	Drop NODE ID	ELAPSED TIME	LONG ELAPSED PERIOD	WAITING FOR VACANCY
1	λ4	1	2	-		-	3	11	REACHED	NONE
2	λ1	2	-	-		-	3	9	NOT-REACHED	NONE
3	λ1	1	-	-		-	2	8	NOT-REACHED	NONE
4	λ5	1	-	-		-	2	3	NOT-REACHED	NONE
5	~~λ3~~	~~2~~	~~-~~	~~-~~		~~-~~	~~3~~	3	NOT-REACHED	NONE
6	λ2	1	-	-		-	2	2	NOT-REACHED	NONE
7	λ2	2	-	-		-	3	2	NOT-REACHED	NONE
8	λ6	2	-	-		-	3	2	NOT-REACHED	NONE
9	-	-	-	-		-	-	-	-	-

1704

FIG.17C

AT COMPLETION OF MOVEMENT FOR OPTIMIZATION

OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION

210

OPTICAL PATH ID	WAVELENGTH	Add NODE ID	Thru NODE ID (1)	Thru NODE ID (2)	...	Thru NODE ID (n)	Drop NODE ID	ELAPSED TIME	LONG ELAPSED PERIOD	WAITING FOR VACANCY
1	λ3	1	2	-		-	3	11	REACHED	NONE
2	λ1	2	-	-		-	3	9	NOT-REACHED	NONE
3	λ1	1	-	-		-	2	8	NOT-REACHED	NONE
4	λ5	1	-	-		-	2	3	NOT-REACHED	NONE
5	-	-	-	-		-	-	-	-	-
6	λ2	1	-	-		-	2	2	NOT-REACHED	NONE
7	λ2	2	-	-		-	3	2	NOT-REACHED	NONE
8	λ6	2	-	-		-	3	2	NOT-REACHED	NONE
9	-	-	-	-		-	-	-	-	-

1705

FIG.18

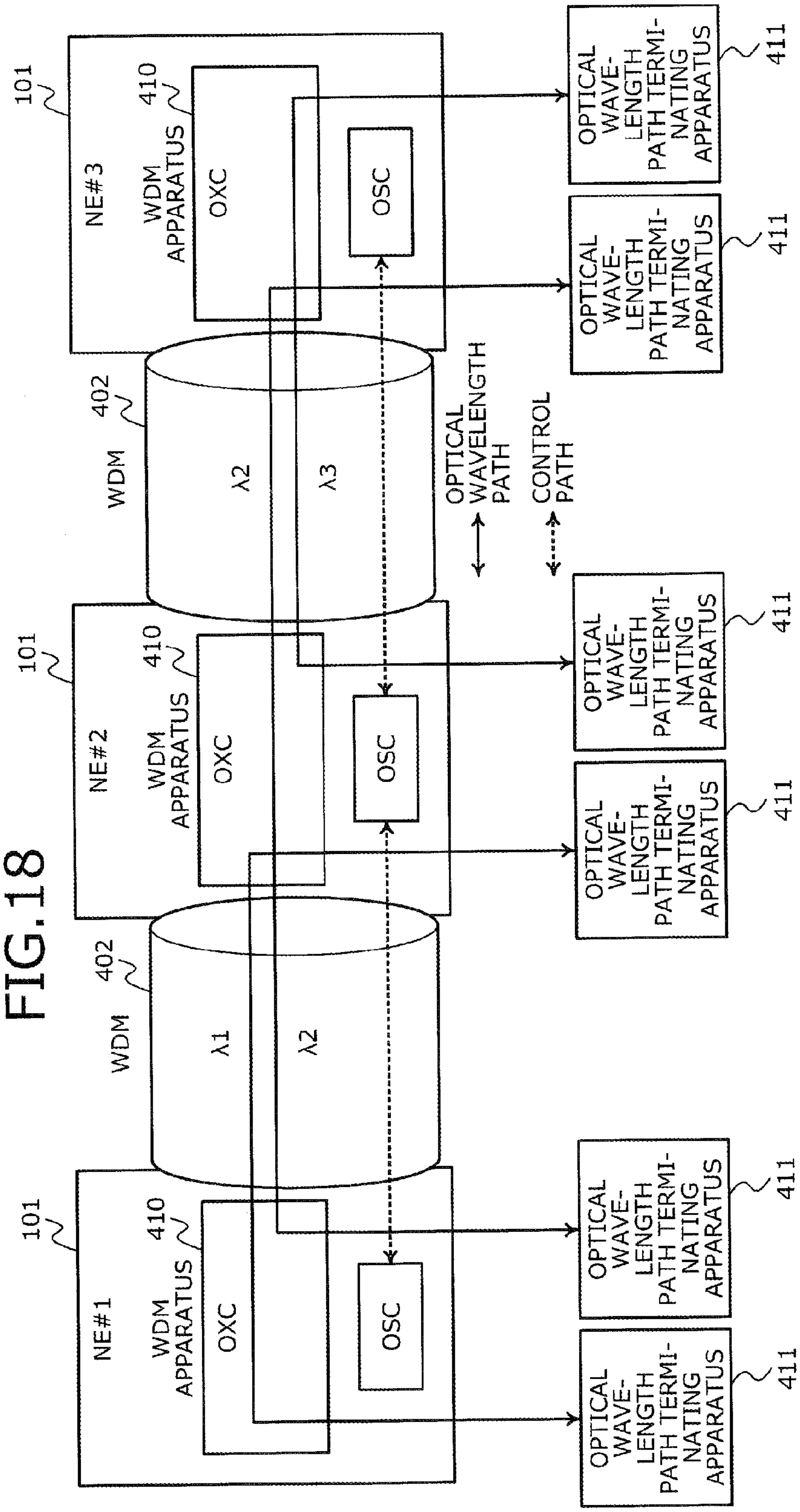
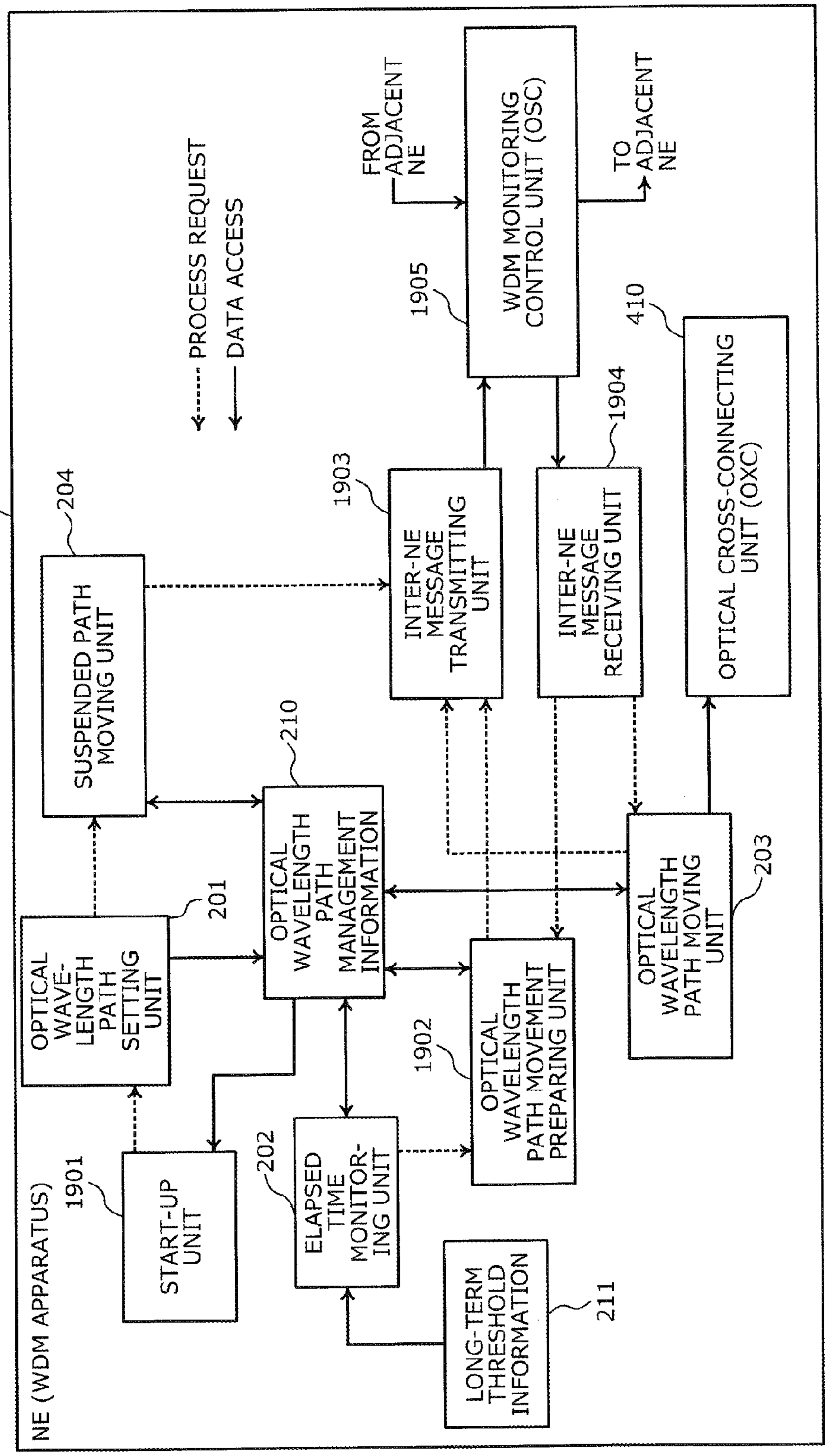

101
NE#1
WDM APPARATUS
410
OXC
OSC
101
NE#2
WDM APPARATUS
410
OXC
OSC
101
NE#3
WDM APPARATUS
410
OXC
OSC
402
WDM
λ1
λ2
402
WDM
λ2
λ3
OPTICAL WAVELENGTH PATH
CONTROL PATH
OPTICAL WAVE-LENGTH PATH TERMI-NATING APPARATUS
411

FIG.19



101
NE (WDM APPARATUS)
PROCESS REQUEST
DATA ACCESS
1901
START-UP UNIT
201
OPTICAL WAVE-LENGTH PATH SETTING UNIT
204
SUSPENDED PATH MOVING UNIT
202
ELAPSED TIME MONITOR-ING UNIT
211
LONG-TERM THRESHOLD INFORMATION
210
OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION
1902
OPTICAL WAVELENGTH PATH MOVEMENT PREPARING UNIT
203
OPTICAL WAVELENGTH PATH MOVING UNIT
1903
INTER-NE MESSAGE TRANSMITTING UNIT
1904
INTER-NE MESSAGE RECEIVING UNIT
410
OPTICAL CROSS-CONNECTING UNIT (OXC)
1905
WDM MONITORING CONTROL UNIT (OSC)
FROM ADJACENT NE
TO ADJACENT NE

FIG.20

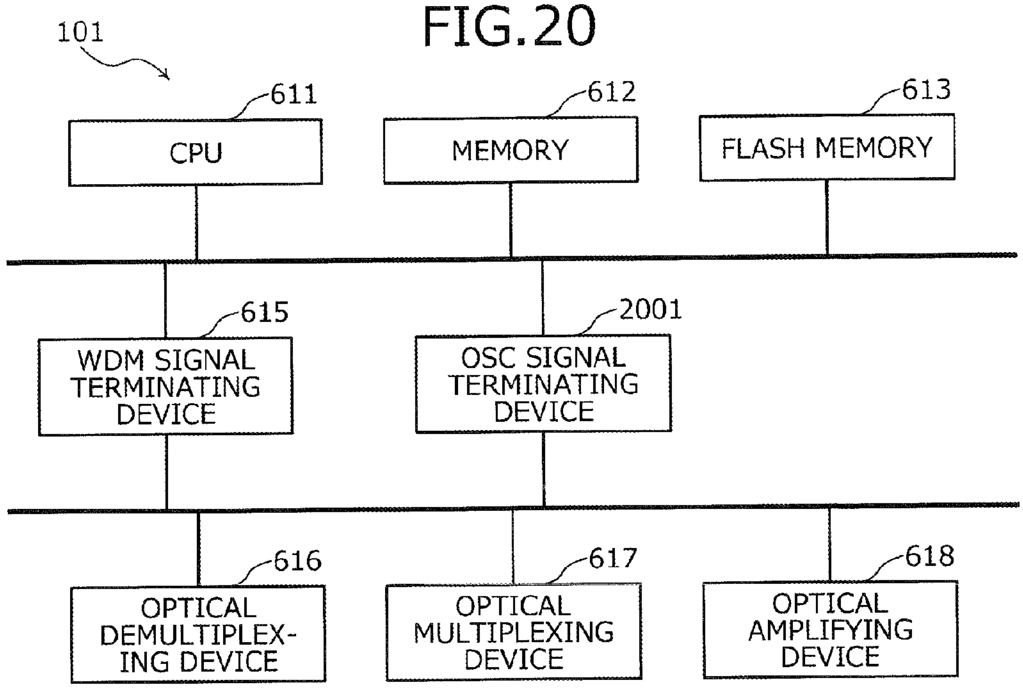


FIG.21A

(a) INTER-NE MESSAGE FORMAT

2101

MESSAGE TYPE	DETAILED TYPE	PARAMETER 1	PARAMETER 2

FIG.21B

(b) INTER-NE MESSAGE TYPES

MESSAGE TYPE	DETAILED TYPE	PARAMETER 1	PARAMETER 2
PATH MOVEMENT	REQUEST	MOVEMENT SOURCE λ	DESTINATION λ
	RESPONSE	MOVEMENT SOURCE λ	DETERMINATION RESULT (OK/NG)
PATH BLOCK CANCELATION	NOTIFICATION	RELEASED λ	-

FIG. 22

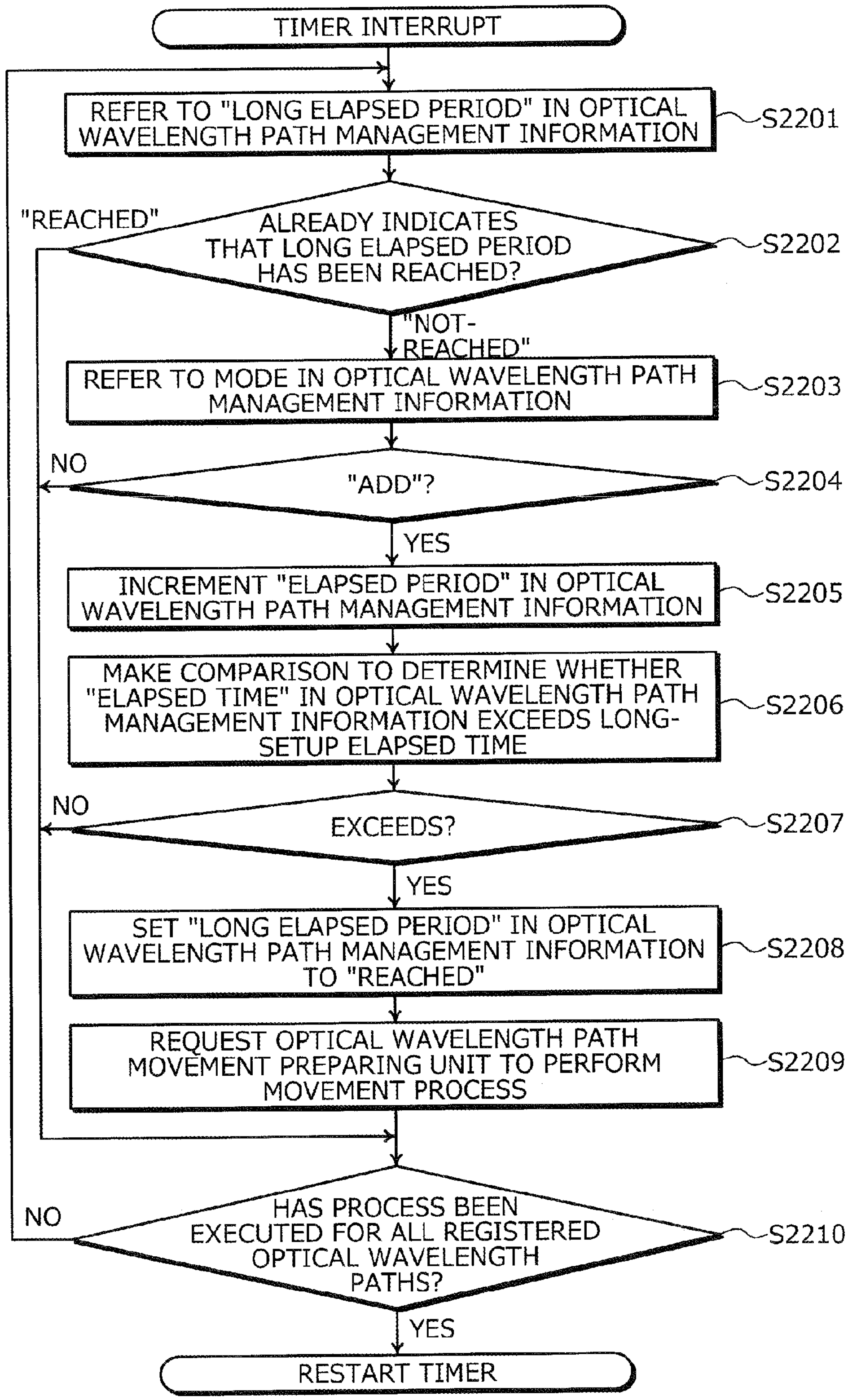
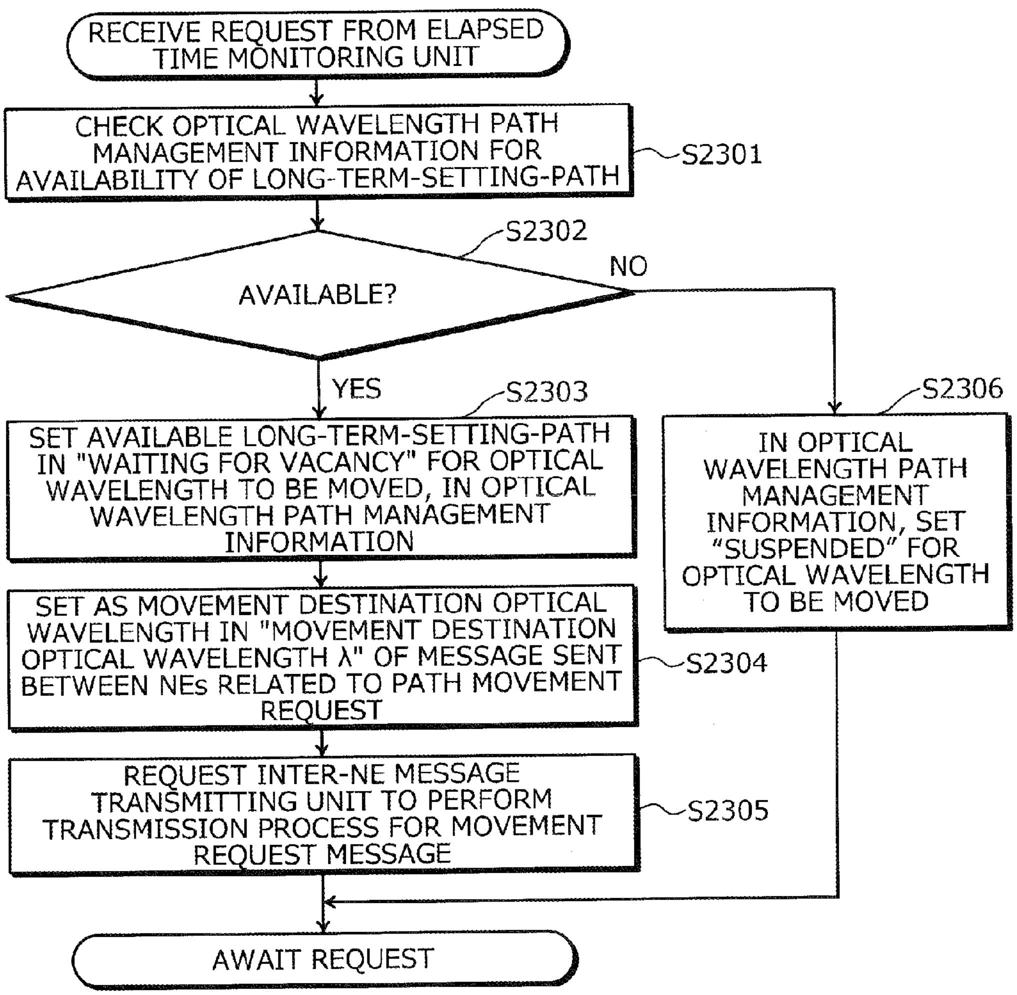

TIMER INTERRUPT
REFER TO "LONG ELAPSED PERIOD" IN OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION
S2201
ALREADY INDICATES THAT LONG ELAPSED PERIOD HAS BEEN REACHED?
S2202
"REACHED"
"NOT-REACHED"
REFER TO MODE IN OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION
S2203
"ADD"?
S2204
NO
YES
INCREMENT "ELAPSED PERIOD" IN OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION
S2205
MAKE COMPARISON TO DETERMINE WHETHER "ELAPSED TIME" IN OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION EXCEEDS LONG-SETUP ELAPSED TIME
S2206
EXCEEDS?
S2207
NO
YES
SET "LONG ELAPSED PERIOD" IN OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION TO "REACHED"
S2208
REQUEST OPTICAL WAVELENGTH PATH MOVEMENT PREPARING UNIT TO PERFORM MOVEMENT PROCESS
S2209
HAS PROCESS BEEN EXECUTED FOR ALL REGISTERED OPTICAL WAVELENGTH PATHS?
S2210
NO
YES
RESTART TIMER

FIG.23



RECEIVE REQUEST FROM ELAPSED TIME MONITORING UNIT
CHECK OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION FOR AVAILABILITY OF LONG-TERM-SETTING-PATH
S2301
S2302
AVAILABLE?
NO
YES
S2303
SET AVAILABLE LONG-TERM-SETTING-PATH IN "WAITING FOR VACANCY" FOR OPTICAL WAVELENGTH TO BE MOVED, IN OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION
S2306
IN OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION, SET "SUSPENDED" FOR OPTICAL WAVELENGTH TO BE MOVED
SET AS MOVEMENT DESTINATION OPTICAL WAVELENGTH IN "MOVEMENT DESTINATION OPTICAL WAVELENGTH λ" OF MESSAGE SENT BETWEEN NEs RELATED TO PATH MOVEMENT REQUEST
S2304
REQUEST INTER-NE MESSAGE TRANSMITTING UNIT TO PERFORM TRANSMISSION PROCESS FOR MOVEMENT REQUEST MESSAGE
S2305
AWAIT REQUEST

FIG.24

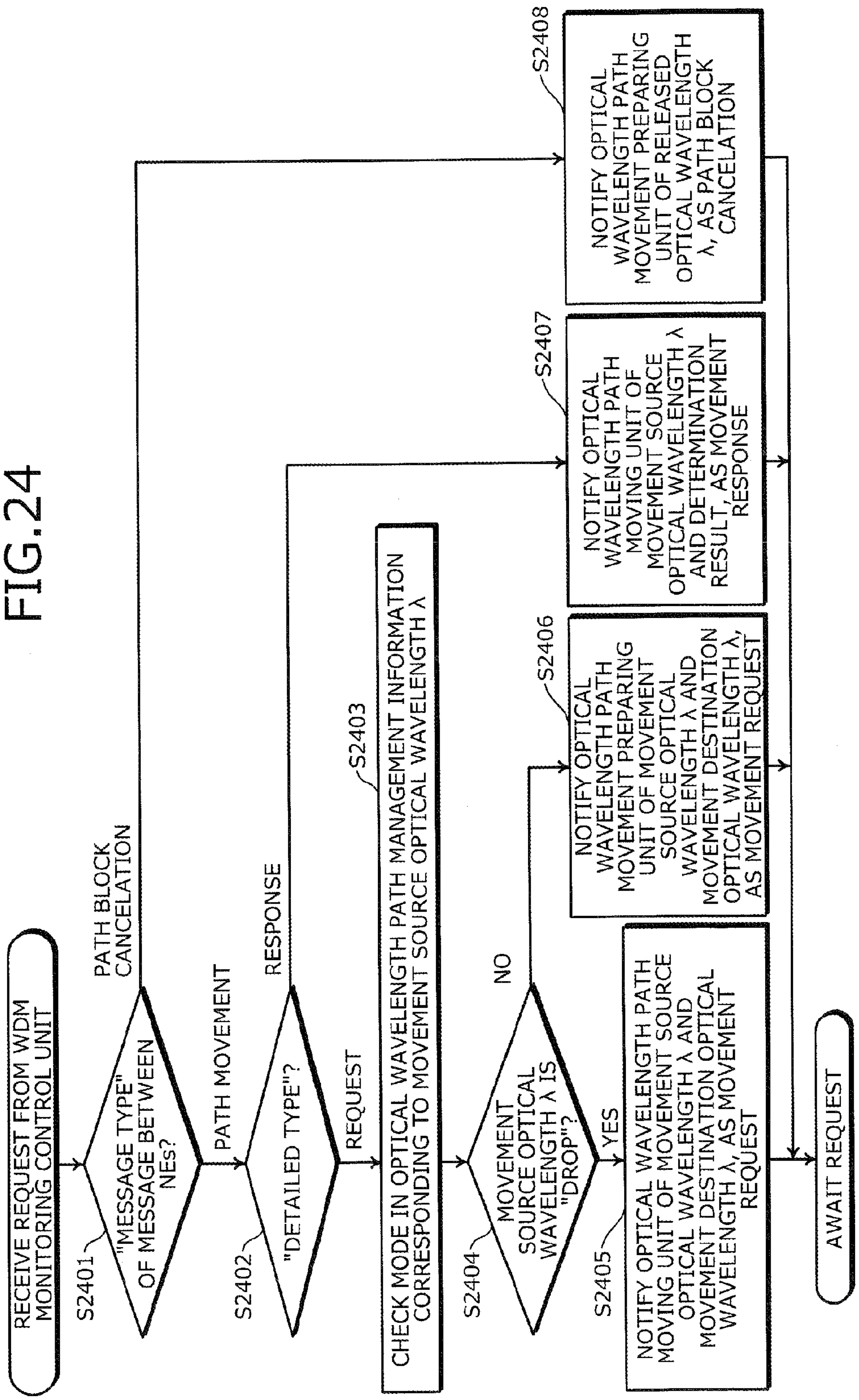

RECEIVE REQUEST FROM WDM MONITORING CONTROL UNIT
S2401
"MESSAGE TYPE" OF MESSAGE BETWEEN NEs?
PATH BLOCK CANCELATION
PATH MOVEMENT
S2402
"DETAILED TYPE"?
RESPONSE
REQUEST
S2403
CHECK MODE IN OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION CORRESPONDING TO MOVEMENT SOURCE OPTICAL WAVELENGTH λ
S2404
MOVEMENT SOURCE OPTICAL WAVELENGTH λ IS "DROP"?
NO
YES
S2405
NOTIFY OPTICAL WAVELENGTH PATH MOVING UNIT OF MOVEMENT SOURCE OPTICAL WAVELENGTH λ AND MOVEMENT DESTINATION OPTICAL WAVELENGTH λ, AS MOVEMENT REQUEST
S2406
NOTIFY OPTICAL WAVELENGTH PATH MOVEMENT PREPARING UNIT OF MOVEMENT SOURCE OPTICAL WAVELENGTH λ AND MOVEMENT DESTINATION OPTICAL WAVELENGTH λ, AS MOVEMENT REQUEST
S2407
NOTIFY OPTICAL WAVELENGTH PATH MOVING UNIT OF MOVEMENT SOURCE OPTICAL WAVELENGTH λ AND DETERMINATION RESULT, AS MOVEMENT RESPONSE
S2408
NOTIFY OPTICAL WAVELENGTH PATH MOVEMENT PREPARING UNIT OF RELEASED OPTICAL WAVELENGTH λ, AS PATH BLOCK CANCELATION
AWAIT REQUEST

FIG.25

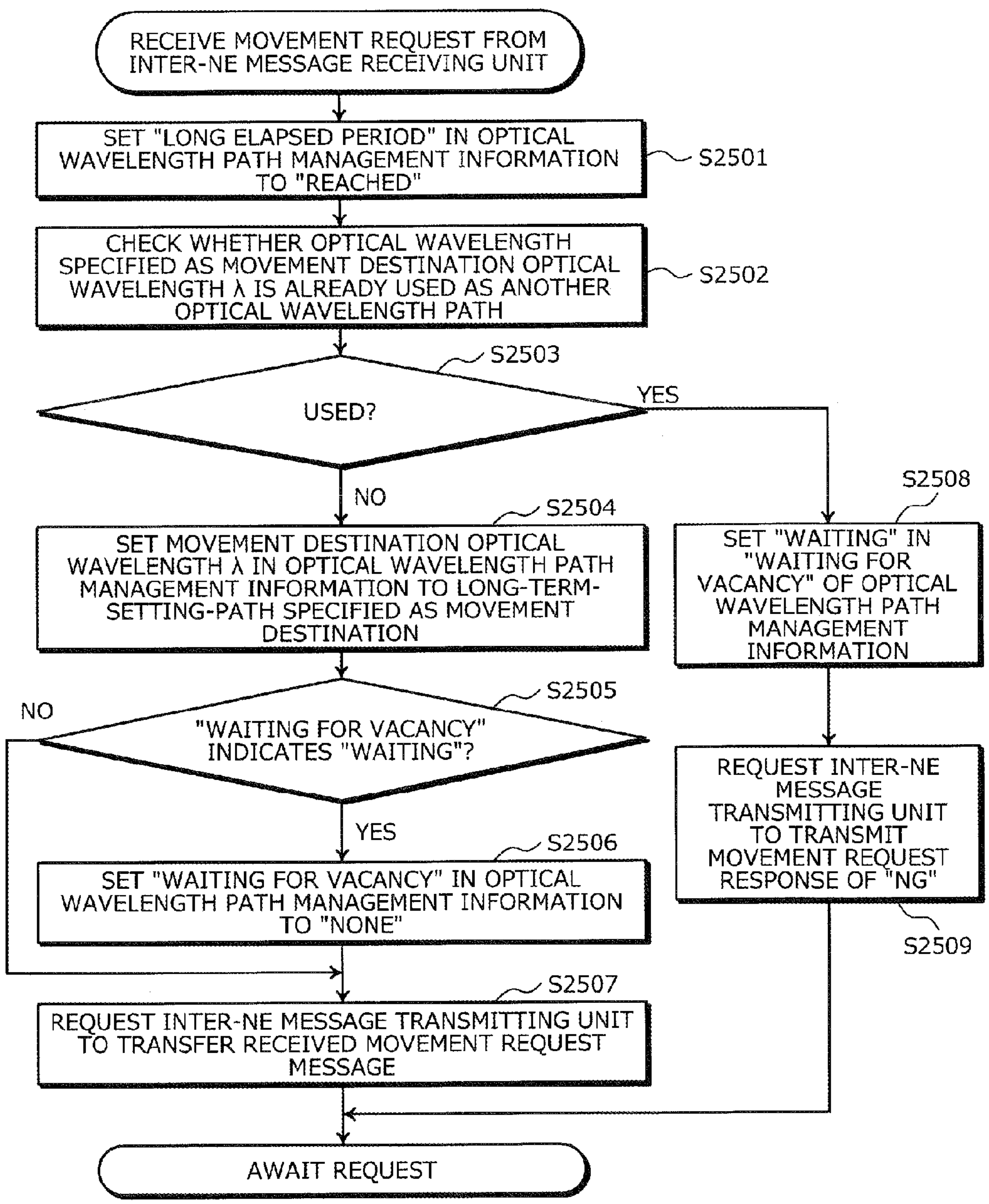
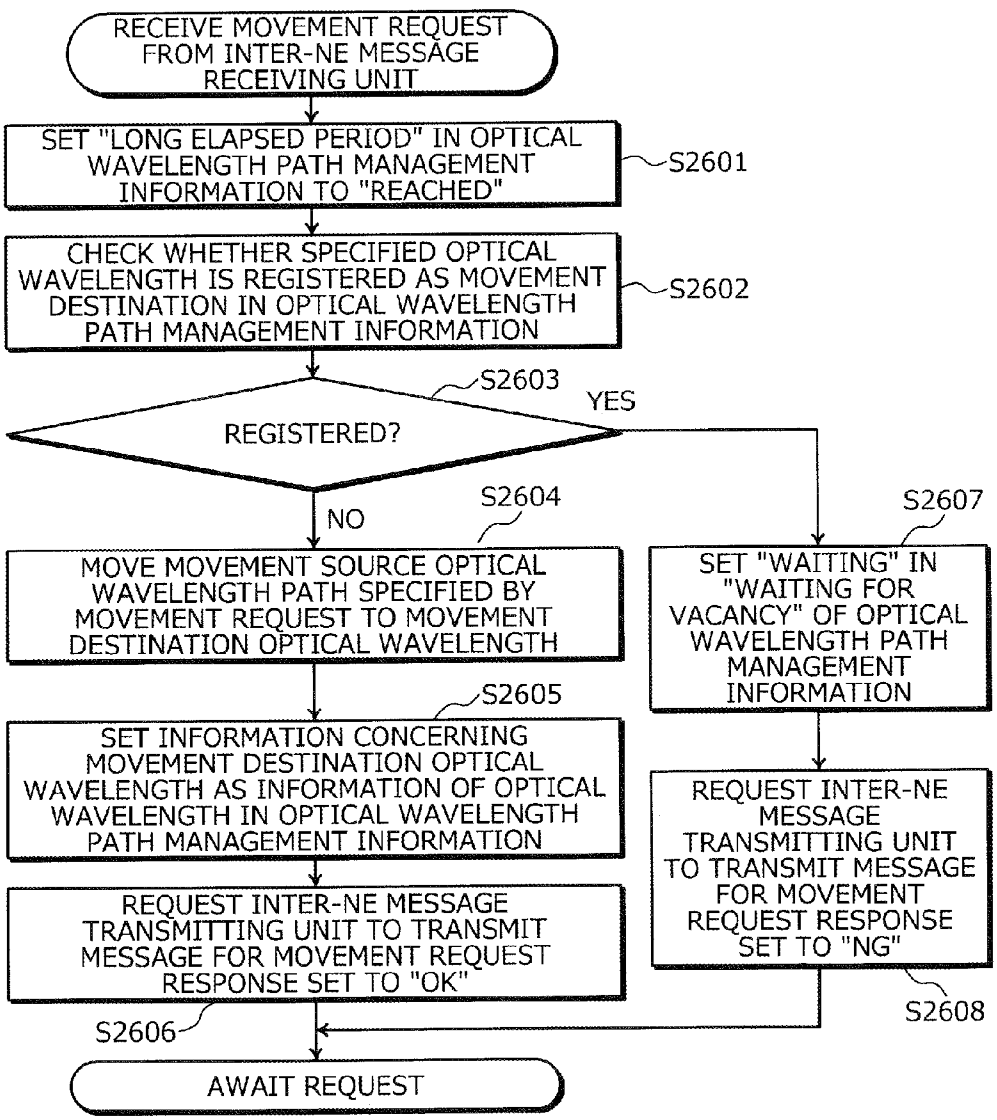

RECEIVE MOVEMENT REQUEST FROM INTER-NE MESSAGE RECEIVING UNIT
SET "LONG ELAPSED PERIOD" IN OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION TO "REACHED"
S2501
CHECK WHETHER OPTICAL WAVELENGTH SPECIFIED AS MOVEMENT DESTINATION OPTICAL WAVELENGTH λ IS ALREADY USED AS ANOTHER OPTICAL WAVELENGTH PATH
S2502
S2503
USED?
YES
NO
SET MOVEMENT DESTINATION OPTICAL WAVELENGTH λ IN OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION TO LONG-TERM-SETTING-PATH SPECIFIED AS MOVEMENT DESTINATION
S2504
S2508
SET "WAITING" IN "WAITING FOR VACANCY" OF OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION
S2505
NO
"WAITING FOR VACANCY" INDICATES "WAITING"?
YES
SET "WAITING FOR VACANCY" IN OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION TO "NONE"
S2506
REQUEST INTER-NE MESSAGE TRANSMITTING UNIT TO TRANSMIT MOVEMENT REQUEST RESPONSE OF "NG"
S2509
S2507
REQUEST INTER-NE MESSAGE TRANSMITTING UNIT TO TRANSFER RECEIVED MOVEMENT REQUEST MESSAGE
AWAIT REQUEST

FIG.26



RECEIVE MOVEMENT REQUEST FROM INTER-NE MESSAGE RECEIVING UNIT
SET "LONG ELAPSED PERIOD" IN OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION TO "REACHED"
S2601
CHECK WHETHER SPECIFIED OPTICAL WAVELENGTH IS REGISTERED AS MOVEMENT DESTINATION IN OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION
S2602
S2603
REGISTERED?
YES
NO
S2604
MOVE MOVEMENT SOURCE OPTICAL WAVELENGTH PATH SPECIFIED BY MOVEMENT REQUEST TO MOVEMENT DESTINATION OPTICAL WAVELENGTH
S2605
SET INFORMATION CONCERNING MOVEMENT DESTINATION OPTICAL WAVELENGTH AS INFORMATION OF OPTICAL WAVELENGTH IN OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION
REQUEST INTER-NE MESSAGE TRANSMITTING UNIT TO TRANSMIT MESSAGE FOR MOVEMENT REQUEST RESPONSE SET TO "OK"
S2606
S2607
SET "WAITING" IN "WAITING FOR VACANCY" OF OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION
REQUEST INTER-NE MESSAGE TRANSMITTING UNIT TO TRANSMIT MESSAGE FOR MOVEMENT REQUEST RESPONSE SET TO "NG"
S2608
AWAIT REQUEST

FIG.27

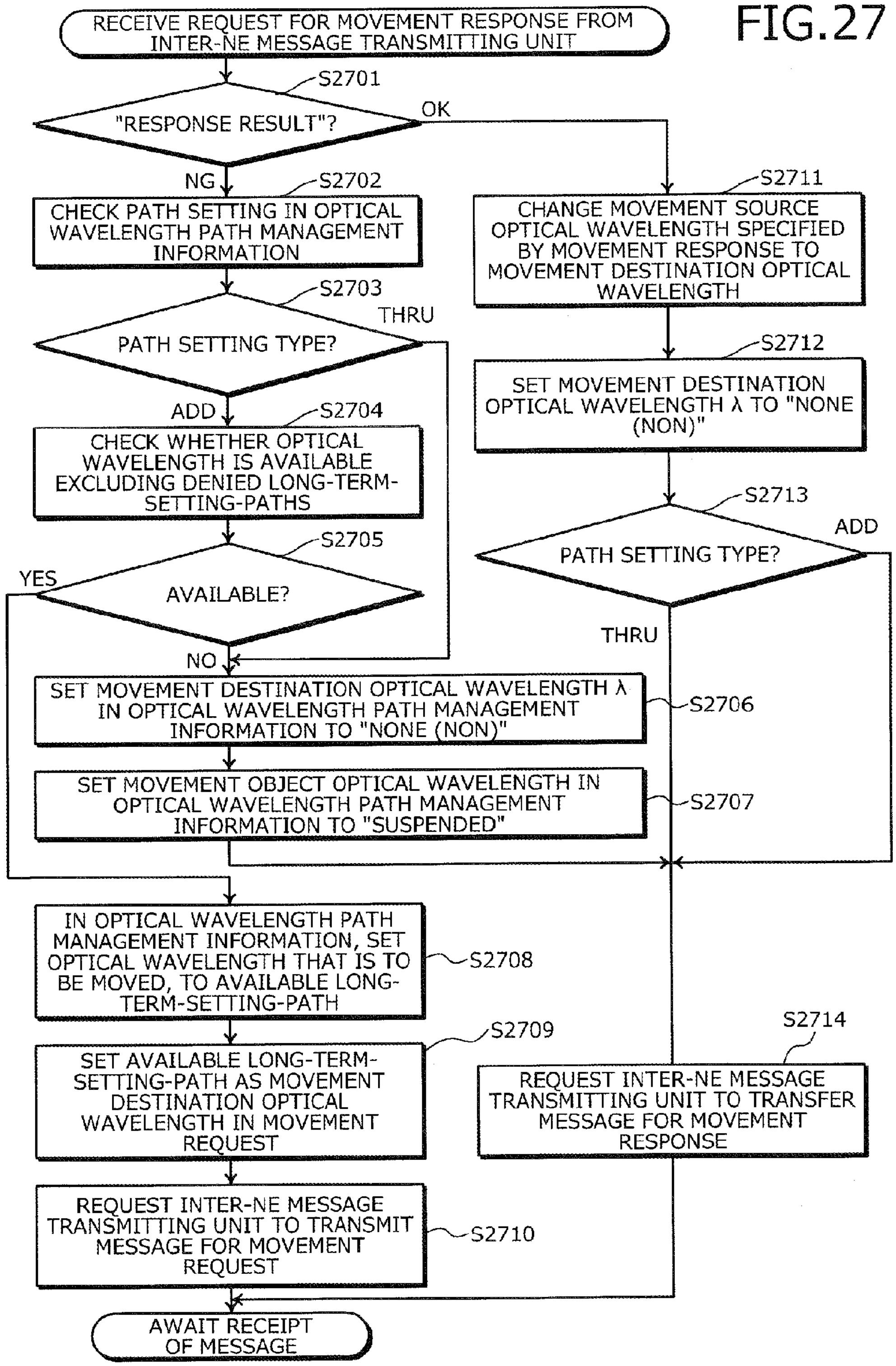
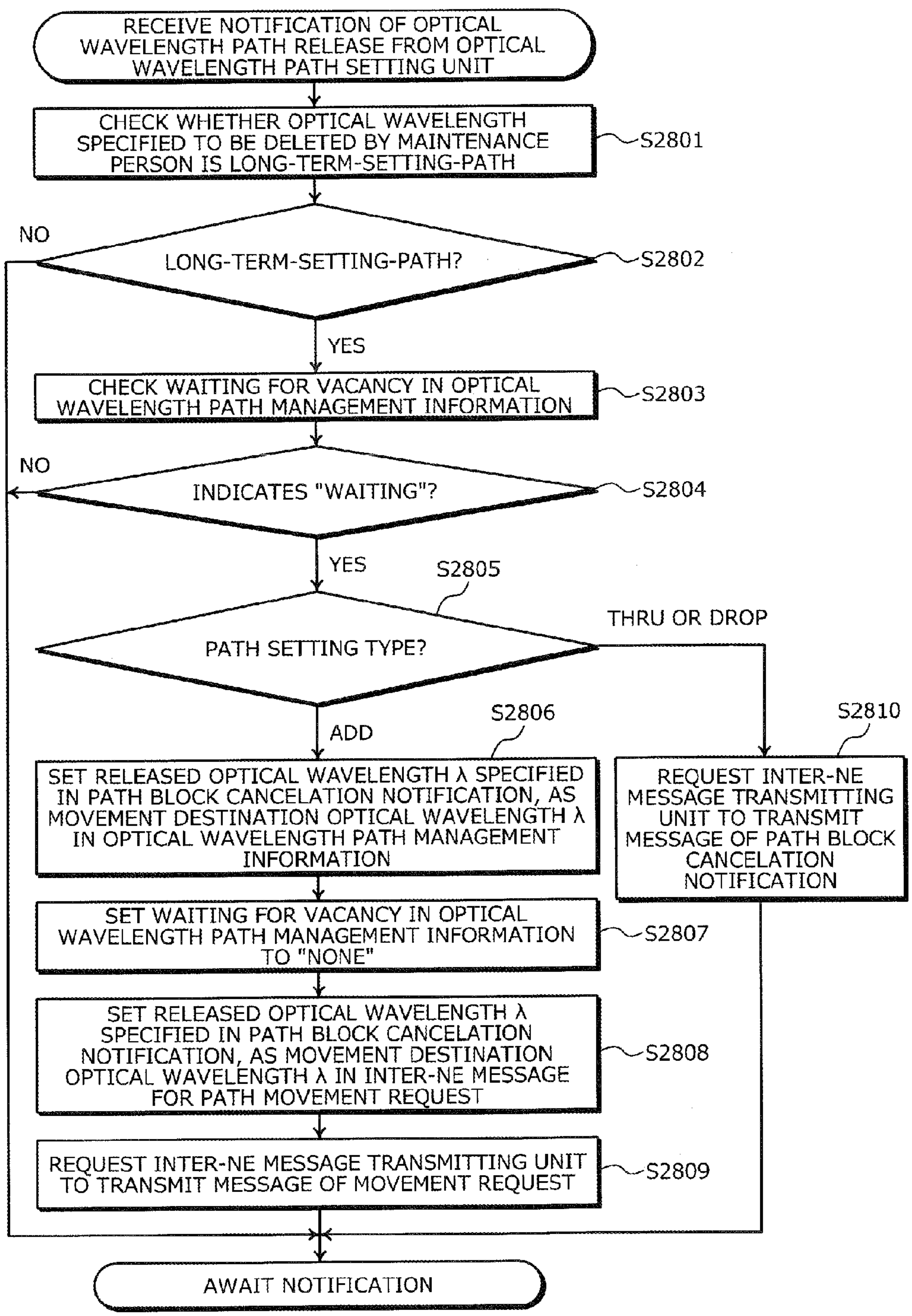

RECEIVE REQUEST FOR MOVEMENT RESPONSE FROM INTER-NE MESSAGE TRANSMITTING UNIT
S2701
"RESPONSE RESULT"?
OK
NG
S2702
CHECK PATH SETTING IN OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION
S2703
PATH SETTING TYPE?
THRU
ADD
S2704
CHECK WHETHER OPTICAL WAVELENGTH IS AVAILABLE EXCLUDING DENIED LONG-TERM-SETTING-PATHS
S2705
AVAILABLE?
YES
NO
S2711
CHANGE MOVEMENT SOURCE OPTICAL WAVELENGTH SPECIFIED BY MOVEMENT RESPONSE TO MOVEMENT DESTINATION OPTICAL WAVELENGTH
S2712
SET MOVEMENT DESTINATION OPTICAL WAVELENGTH λ TO "NONE (NON)"
S2713
PATH SETTING TYPE?
ADD
THRU
SET MOVEMENT DESTINATION OPTICAL WAVELENGTH λ IN OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION TO "NONE (NON)"
S2706
SET MOVEMENT OBJECT OPTICAL WAVELENGTH IN OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION TO "SUSPENDED"
S2707
IN OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION, SET OPTICAL WAVELENGTH THAT IS TO BE MOVED, TO AVAILABLE LONG-TERM-SETTING-PATH
S2708
S2709
SET AVAILABLE LONG-TERM-SETTING-PATH AS MOVEMENT DESTINATION OPTICAL WAVELENGTH IN MOVEMENT REQUEST
S2714
REQUEST INTER-NE MESSAGE TRANSMITTING UNIT TO TRANSFER MESSAGE FOR MOVEMENT RESPONSE
REQUEST INTER-NE MESSAGE TRANSMITTING UNIT TO TRANSMIT MESSAGE FOR MOVEMENT REQUEST
S2710
AWAIT RECEIPT OF MESSAGE

FIG.28



RECEIVE NOTIFICATION OF OPTICAL WAVELENGTH PATH RELEASE FROM OPTICAL WAVELENGTH PATH SETTING UNIT
CHECK WHETHER OPTICAL WAVELENGTH SPECIFIED TO BE DELETED BY MAINTENANCE PERSON IS LONG-TERM-SETTING-PATH
S2801
LONG-TERM-SETTING-PATH?
S2802
NO
YES
CHECK WAITING FOR VACANCY IN OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION
S2803
INDICATES "WAITING"?
S2804
NO
YES
S2805
PATH SETTING TYPE?
THRU OR DROP
ADD
S2806
SET RELEASED OPTICAL WAVELENGTH λ SPECIFIED IN PATH BLOCK CANCELATION NOTIFICATION, AS MOVEMENT DESTINATION OPTICAL WAVELENGTH λ IN OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION
S2810
REQUEST INTER-NE MESSAGE TRANSMITTING UNIT TO TRANSMIT MESSAGE OF PATH BLOCK CANCELATION NOTIFICATION
SET WAITING FOR VACANCY IN OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION TO "NONE"
S2807
SET RELEASED OPTICAL WAVELENGTH λ SPECIFIED IN PATH BLOCK CANCELATION NOTIFICATION, AS MOVEMENT DESTINATION OPTICAL WAVELENGTH λ IN INTER-NE MESSAGE FOR PATH MOVEMENT REQUEST
S2808
REQUEST INTER-NE MESSAGE TRANSMITTING UNIT TO TRANSMIT MESSAGE OF MOVEMENT REQUEST
S2809
AWAIT NOTIFICATION

FIG.29

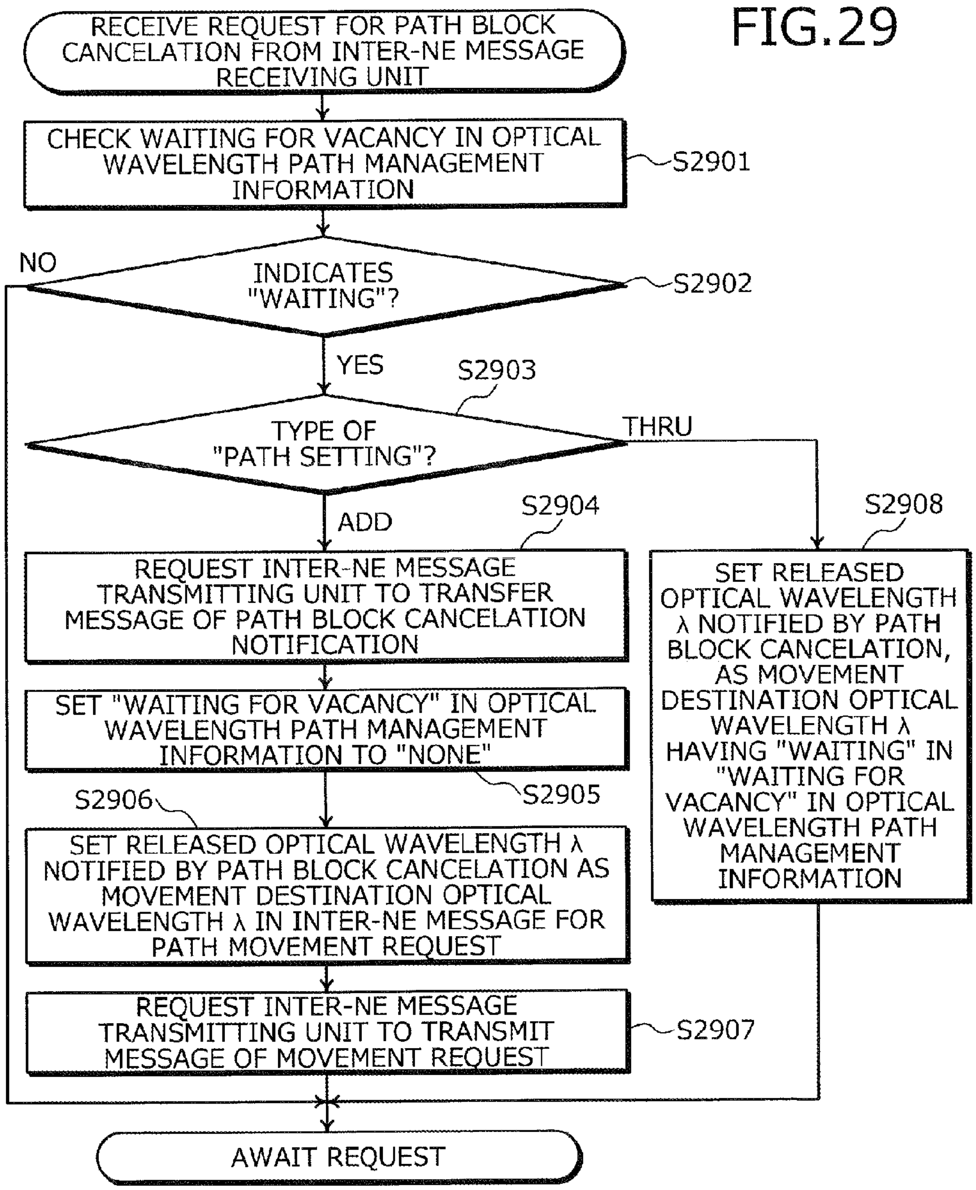

RECEIVE REQUEST FOR PATH BLOCK CANCELATION FROM INTER-NE MESSAGE RECEIVING UNIT
CHECK WAITING FOR VACANCY IN OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION
S2901
INDICATES "WAITING"?
S2902
NO
YES
S2903
TYPE OF "PATH SETTING"?
THRU
ADD
S2904
REQUEST INTER-NE MESSAGE TRANSMITTING UNIT TO TRANSFER MESSAGE OF PATH BLOCK CANCELATION NOTIFICATION
SET "WAITING FOR VACANCY" IN OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION TO "NONE"
S2905
S2906
SET RELEASED OPTICAL WAVELENGTH λ NOTIFIED BY PATH BLOCK CANCELATION AS MOVEMENT DESTINATION OPTICAL WAVELENGTH λ IN INTER-NE MESSAGE FOR PATH MOVEMENT REQUEST
REQUEST INTER-NE MESSAGE TRANSMITTING UNIT TO TRANSMIT MESSAGE OF MOVEMENT REQUEST
S2907
S2908
SET RELEASED OPTICAL WAVELENGTH λ NOTIFIED BY PATH BLOCK CANCELATION, AS MOVEMENT DESTINATION OPTICAL WAVELENGTH λ HAVING "WAITING" IN "WAITING FOR VACANCY" IN OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION
AWAIT REQUEST

FIG. 30

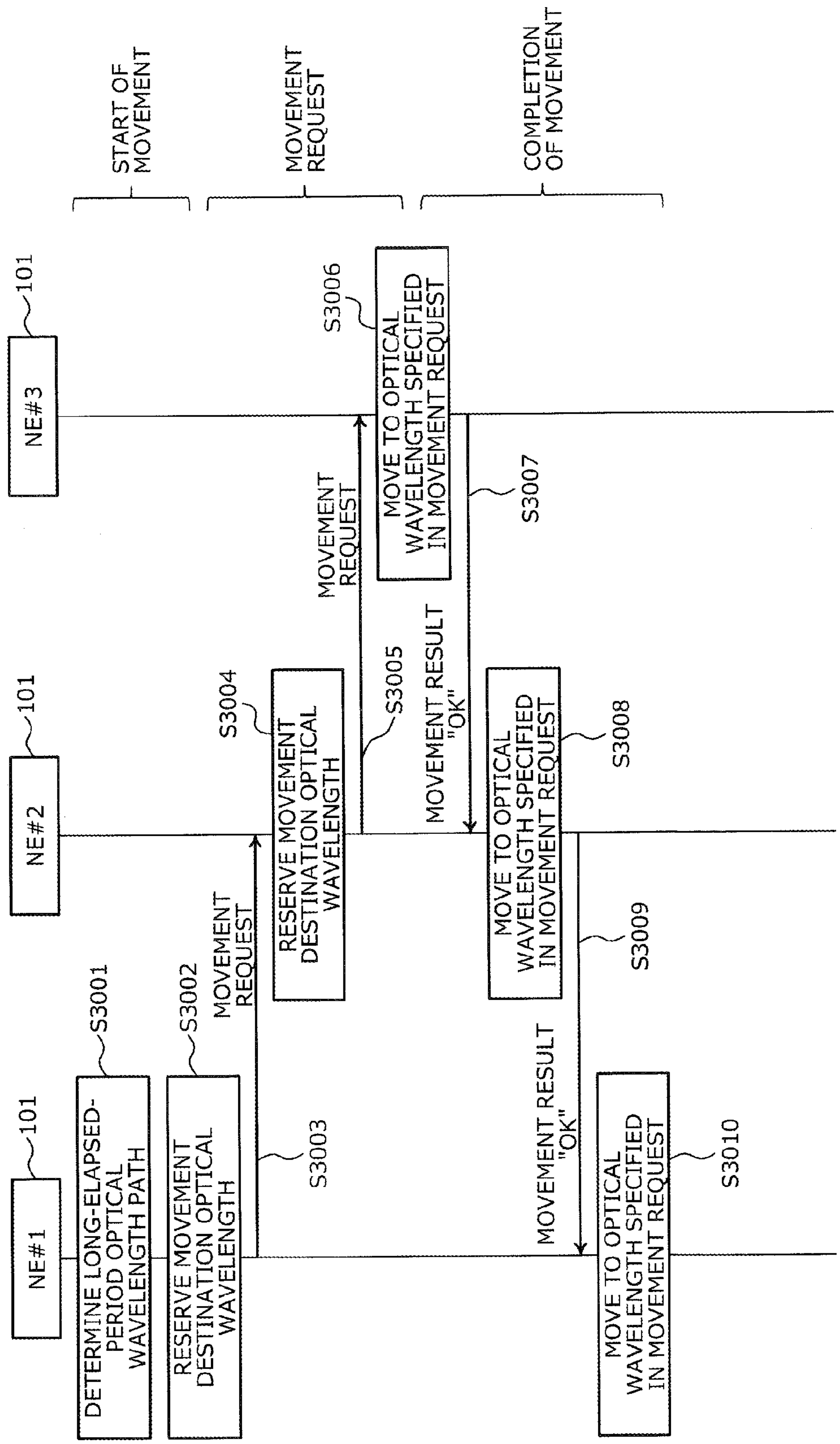
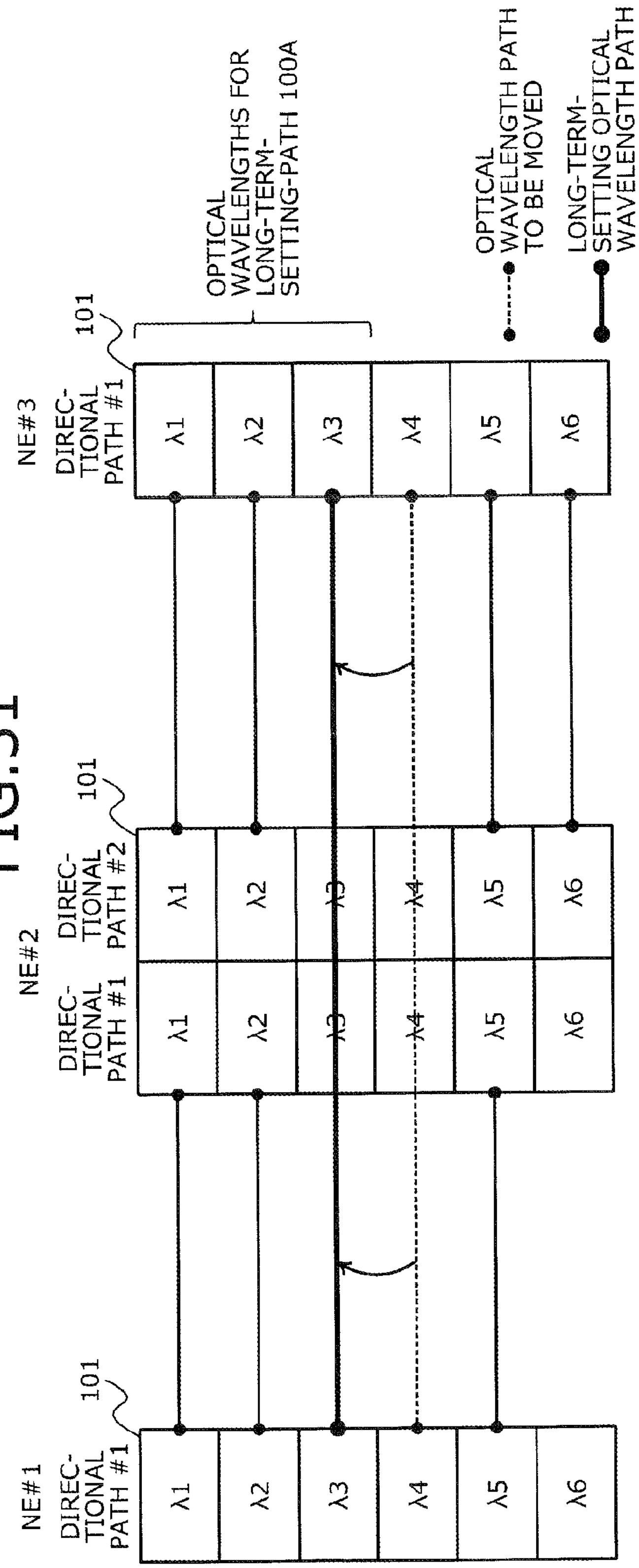

START OF MOVEMENT
MOVEMENT REQUEST
COMPLETION OF MOVEMENT
NE#1
NE#2
NE#3
101
101
101
S3001
DETERMINE LONG-ELAPSED-PERIOD OPTICAL WAVELENGTH PATH
S3002
RESERVE MOVEMENT DESTINATION OPTICAL WAVELENGTH
S3003
MOVEMENT REQUEST
S3004
RESERVE MOVEMENT DESTINATION OPTICAL WAVELENGTH
S3005
MOVEMENT REQUEST
S3006
MOVE TO OPTICAL WAVELENGTH SPECIFIED IN MOVEMENT REQUEST
S3007
MOVEMENT RESULT "OK"
S3008
MOVE TO OPTICAL WAVELENGTH SPECIFIED IN MOVEMENT REQUEST
S3009
MOVEMENT RESULT "OK"
S3010
MOVE TO OPTICAL WAVELENGTH SPECIFIED IN MOVEMENT REQUEST

FIG.31



NE#1
DIREC-TIONAL PATH #1
NE#2
DIREC-TIONAL PATH #1
DIREC-TIONAL PATH #2
NE#3
DIREC-TIONAL PATH #1
λ1
λ2
λ3
λ4
λ5
λ6
101
OPTICAL WAVELENGTHS FOR LONG-TERM-SETTING-PATH 100A
OPTICAL WAVELENGTH PATH TO BE MOVED
LONG-TERM-SETTING OPTICAL WAVELENGTH PATH

FIG.32A

210

AT START OF MOVEMENT FOR OPTIMIZATION

3202 3201

【NE#1】 OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION

OPTICAL PATH ID	DIREC-TION	WAVE-LENGTH	MODE	NE COUNT	DESTI-NATION λ	ELAPSED TIME	LONG ELAPSED PERIOD	WAITING FOR VACANCY
1	1	λ4	Add	3	λ3	10	REACHED	NONE
2	1	λ1	Add	2	Non	8	NOT-REACHED	NONE
3	1	λ5	Add	2	Non	3	NOT-REACHED	NONE
4	1	λ2	Add	2	Non	2	NOT-REACHED	NONE
-	-	-	-	-	-	-	-	-

【NE#2】 OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION

OPTICAL PATH ID	DIREC-TION	WAVE-LENGTH	MODE	NE COUNT	DESTI-NATION λ	ELAPSED TIME	LONG ELAPSED PERIOD	WAITING FOR VACANCY
1	1	λ4	Thru	3	Non	0	NOT-REACHED	NONE
2	2	λ4	Thru	3	Non	0	NOT-REACHED	NONE
3	2	λ1	Add	2	Non	9	NOT-REACHED	NONE
4	1	λ1	Drop	2	Non	0	NOT-REACHED	NONE
5	1	λ5	Drop	2	Non	0	NOT-REACHED	NONE
6	2	λ5	Add	2	Non	3	NOT-REACHED	NONE
7	1	λ2	Drop	2	Non	0	NOT-REACHED	NONE
8	2	λ6	Add	2	Non	2	NOT-REACHED	NONE
-	-	-	-	-	-	-	-	-

【NE#3】 OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION

OPTICAL PATH ID	DIREC-TION	WAVE-LENGTH	MODE	NE COUNT	DESTI-NATION λ	ELAPSED TIME	LONG ELAPSED PERIOD	WAITING FOR VACANCY
1	1	λ4	Drop	3	Non	0	NOT-REACHED	NONE
2	1	λ1	Drop	2	Non	0	NOT-REACHED	NONE
3	1	λ5	Drop	2	Non	0	NOT-REACHED	NONE
4	1	λ2	Drop	2	Non	0	NOT-REACHED	NONE
5	1	λ6	Drop	2	Non	0	NOT-REACHED	NONE
-	-	-	-	-	-	-	-	-

FIG.32B

AT TIME OF MOVEMENT REQUEST

210

【NE#1】 OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION

OPTICAL PATH ID	DIREC-TION	WAVE-LENGTH	MODE	NE COUNT	DESTI-NATIONλ	ELAPSED TIME	LONG ELAPSED PERIOD	WAITING FOR VACANCY
1	1	λ4	Add	3	λ3	10	REACHED	NONE
2	1	λ1	Add	2	Non	8	NOT-REACHED	NONE
3	1	λ5	Add	2	Non	3	NOT-REACHED	NONE
4	1	λ2	Add	2	Non	2	NOT-REACHED	NONE
-	-	-	-	-	-	-	-	-

【NE#2】 OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION

3211

OPTICAL PATH ID	DIREC-TION	WAVE-LENGTH	MODE	NE COUNT	DESTI-NATIONλ	ELAPSED TIME	LONG ELAPSED PERIOD	WAITING FOR VACANCY
1	1	λ4	Thru	3	λ3	0	REACHED	NONE
2	2	λ4	Thru	3	λ3	0	REACHED	NONE
3	2	λ1	Add	2	Non	9	NOT-REACHED	NONE
4	1	λ1	Drop	2	Non	0	NOT-REACHED	NONE
5	1	λ5	Drop	2	Non	0	NOT-REACHED	NONE
6	2	λ5	Add	2	Non	3	NOT-REACHED	NONE
7	1	λ2	Drop	2	Non	0	NOT-REACHED	NONE
8	2	λ6	Add	2	Non	2	NOT-REACHED	NONE
-	-	-	-	-	-	-	-	-

【NE#3】 OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION

3212

OPTICAL PATH ID	DIREC-TION	WAVE-LENGTH	MODE	NE COUNT	DESTI-NATIONλ	ELAPSED TIME	LONG ELAPSED PERIOD	WAITING FOR VACANCY
1	1	λ3	Drop	3	Non	0	REACHED	NONE
2	1	λ1	Drop	2	Non	0	NOT-REACHED	NONE
3	1	λ5	Drop	2	Non	0	NOT-REACHED	NONE
4	1	λ2	Drop	2	Non	0	NOT-REACHED	NONE
5	1	λ6	Drop	2	Non	0	NOT-REACHED	NONE
-	-	-	-	-	-	-	-	-

FIG.32C

AT COMPLETION OF MOVEMENT FOR OPTIMIZATION

210

【NE#1】 OPTICAL WAVE-LENGTH PATH MANAGEMENT INFORMATION

3222

OPTICAL PATH ID	DIREC-TION	WAVE-LENGTH	MODE	NE COUNT	DESTI-NATION λ	ELAPSED TIME	LONG ELAPSED PERIOD	WAITING FOR VACANCY
1	1	λ3	Add	3	Non	10	REACHED	NONE
2	1	λ1	Add	2	Non	8	NOT-REACHED	NONE
3	1	λ5	Add	2	Non	3	NOT-REACHED	NONE
4	1	λ2	Add	2	Non	2	NOT-REACHED	NONE
-	-	-	-	-	-	-	-	-

【NE#2】 OPTICAL WAVE-LENGTH PATH MANAGEMENT INFORMATION

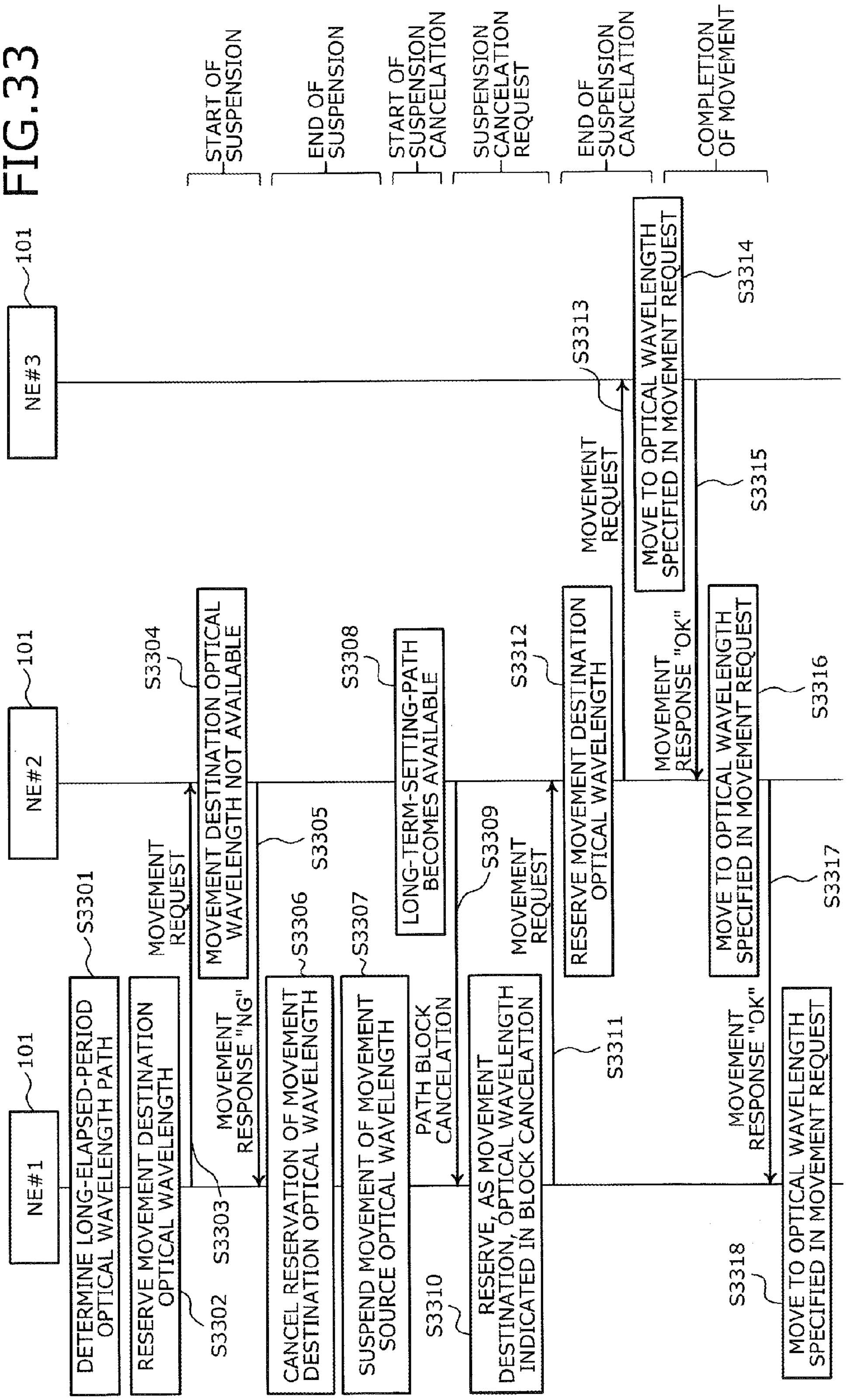
3221

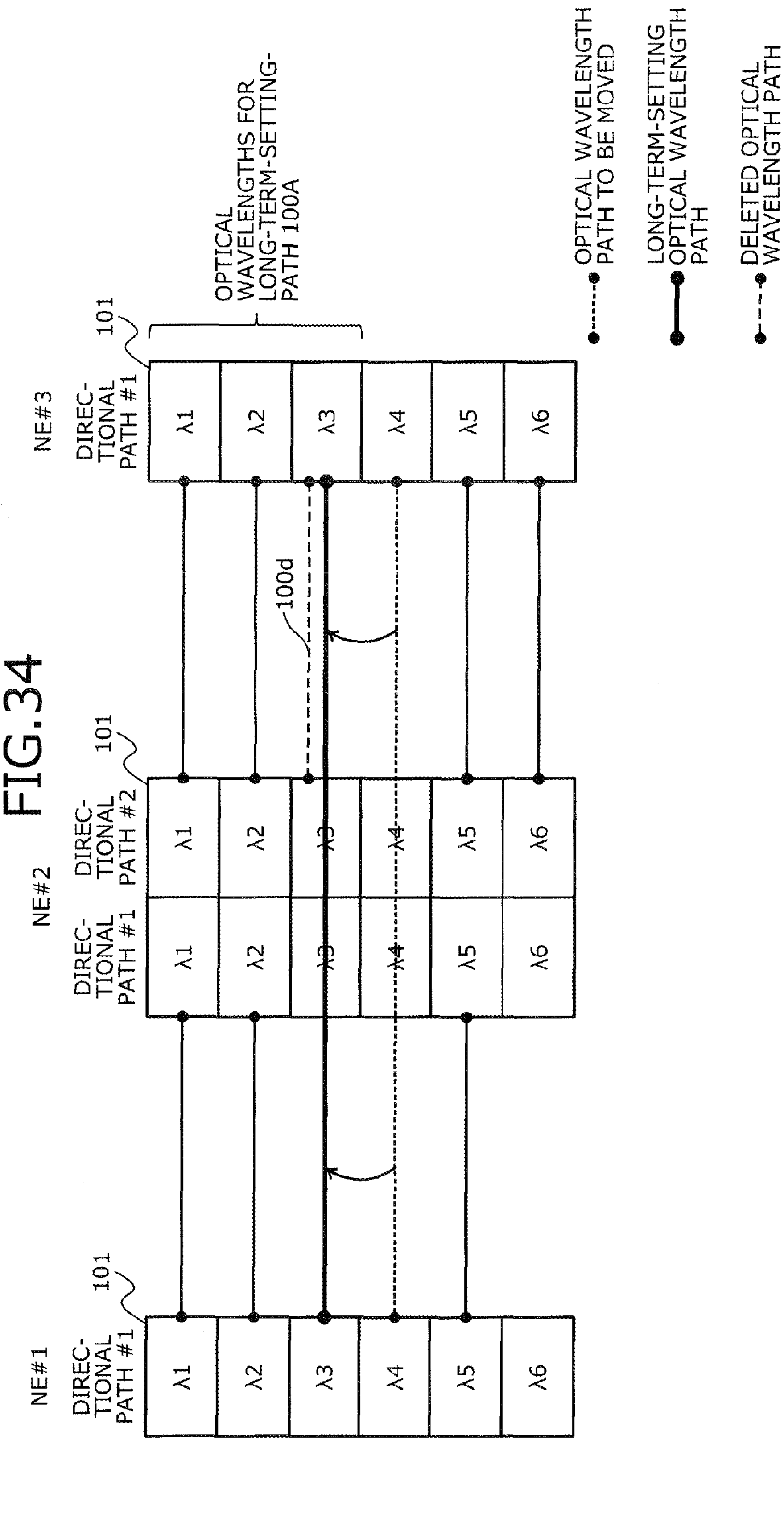
OPTICAL PATH ID	DIREC-TION	WAVE-LENGTH	MODE	NE COUNT	DESTI-NATION λ	ELAPSED TIME	LONG ELAPSED PERIOD	WAITING FOR VACANCY
1	1	λ3	Thru	3	Non	0	REACHED	NONE
2	2	λ3	Thru	3	Non	0	REACHED	NONE
3	2	λ1	Add	2	Non	9	NOT-REACHED	NONE
4	1	λ1	Drop	2	Non	0	NOT-REACHED	NONE
5	1	λ5	Drop	2	Non	0	NOT-REACHED	NONE
6	2	λ5	Add	2	Non	3	NOT-REACHED	NONE
7	1	λ2	Drop	2	Non	0	NOT-REACHED	NONE
8	2	λ6	Add	2	Non	2	NOT-REACHED	NONE
-	-	-	-	-	-	-	-	-

【NE#3】 OPTICAL WAVE-LENGTH PATH MANAGEMENT INFORMATION

OPTICAL PATH ID	DIREC-TION	WAVE-LENGTH	MODE	NE COUNT	DESTI-NATION λ	ELAPSED TIME	LONG ELAPSED PERIOD	WAITING FOR VACANCY
1	1	λ3	Drop	3	Non	0	REACHED	NONE
2	1	λ1	Drop	2	Non	0	NOT-REACHED	NONE
3	1	λ5	Drop	2	Non	0	NOT-REACHED	NONE
4	1	λ2	Drop	2	Non	0	NOT-REACHED	NONE
5	1	λ6	Drop	2	Non	0	NOT-REACHED	NONE
-	-	-	-	-	-	-	-	-

FIG.33


NE#1
NE#2
NE#3
101
101
101
START OF SUSPENSION
END OF SUSPENSION
START OF SUSPENSION CANCELATION
SUSPENSION CANCELATION REQUEST
END OF SUSPENSION CANCELATION
COMPLETION OF MOVEMENT
DETERMINE LONG-ELAPSED-PERIOD OPTICAL WAVELENGTH PATH
S3301
RESERVE MOVEMENT DESTINATION OPTICAL WAVELENGTH
S3302
MOVEMENT REQUEST
S3303
MOVEMENT DESTINATION OPTICAL WAVELENGTH NOT AVAILABLE
S3304
MOVEMENT RESPONSE "NG"
S3305
CANCEL RESERVATION OF MOVEMENT DESTINATION OPTICAL WAVELENGTH
S3306
SUSPEND MOVEMENT OF MOVEMENT SOURCE OPTICAL WAVELENGTH
S3307
LONG-TERM-SETTING-PATH BECOMES AVAILABLE
S3308
PATH BLOCK CANCELATION
S3309
RESERVE, AS MOVEMENT DESTINATION, OPTICAL WAVELENGTH INDICATED IN BLOCK CANCELATION
S3310
MOVEMENT REQUEST
S3311
RESERVE MOVEMENT DESTINATION OPTICAL WAVELENGTH
S3312
MOVEMENT REQUEST
S3313
MOVE TO OPTICAL WAVELENGTH SPECIFIED IN MOVEMENT REQUEST
S3314
MOVEMENT RESPONSE "OK"
S3315
MOVE TO OPTICAL WAVELENGTH SPECIFIED IN MOVEMENT REQUEST
S3316
MOVEMENT RESPONSE "OK"
S3317
MOVE TO OPTICAL WAVELENGTH SPECIFIED IN MOVEMENT REQUEST
S3318



NE#1
DIREC-TIONAL PATH #1
NE#2
DIREC-TIONAL PATH #1
DIREC-TIONAL PATH #2
NE#3
DIREC-TIONAL PATH #1
101
λ1
λ2
λ3
λ4
λ5
λ6
100d
OPTICAL WAVELENGTHS FOR LONG-TERM-SETTING-PATH 100A
OPTICAL WAVELENGTH PATH TO BE MOVED
LONG-TERM-SETTING OPTICAL WAVELENGTH PATH
DELETED OPTICAL WAVELENGTH PATH

FIG.34

FIG.35AA

AT START OF SUSPENSION OF MOVEMENT

210 3502 3501

[NE#1] OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION

OPTICAL PATH ID	DIREC-TION	WAVE-LENGTH	MODE	NE COUNT	DESTI-NATION λ	ELAPSED TIME	LONG ELAPSED PERIOD	WAITING FOR VACANCY
1	1	λ4	Add	3	λ3	10	REACHED	NONE
2	1	λ1	Add	2	Non	8	NOT-REACHED	NONE
3	1	λ5	Add	2	Non	3	NOT-REACHED	NONE
4	1	λ2	Add	2	Non	2	NOT-REACHED	NONE
-	-	-	-	-	-	-	-	-

[NE#2] OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION

3503

OPTICAL PATH ID	DIREC-TION	WAVE-LENGTH	MODE	NE COUNT	DESTI-NATION λ	ELAPSED TIME	LONG ELAPSED PERIOD	WAITING FOR VACANCY
1	1	λ4	Thru	3	λ3	0	REACHED	NONE
2	2	λ4	Thru	3	Non	0	REACHED	WAITING
3	2	λ1	Add	2	Non	9	NOT-REACHED	NONE
4	1	λ1	Drop	2	Non	0	NOT-REACHED	NONE
5	2	λ3	Add	2	Non	5	NOT-REACHED	NONE
6	1	λ5	Drop	2	Non	0	NOT-REACHED	NONE
7	2	λ5	Add	2	Non	3	NOT-REACHED	NONE
8	1	λ2	Drop	2	Non	0	NOT-REACHED	NONE
9	2	λ6	Add	2	Non	2	NOT-REACHED	NONE
-	-	-	-	-	-	-	-	-

[NE#3] OPTICAL WAVELENGTH PATH MANAGEMENT INFORMATION

OPTICAL PATH ID	DIREC-TION	WAVE-LENGTH	MODE	NE COUNT	DESTI-NATION λ	ELAPSED TIME	LONG ELAPSED PERIOD	WAITING FOR VACANCY
1	1	λ4	Drop	3	Non	0	NOT-REACHED	NONE
2	1	λ1	Drop	2	Non	0	NOT-REACHED	NONE
3	1	λ3	Drop	2	Non	0	NOT-REACHED	NONE
4	1	λ5	Drop	2	Non	0	NOT-REACHED	NONE
5	1	λ2	Drop	2	Non	0	NOT-REACHED	NONE
6	1	λ6	Drop	2	Non	0	NOT-REACHED	NONE
-	-	-	-	-	-	-	-	-

AT END OF SUSPENSION

FIG.35AB

210

【NE#1】 OPTICAL WAVE-LENGTH PATH MANAGEMENT INFORMATION

3506 3507

OPTICAL PATH ID	DIREC-TION	WAVE-LENGTH	MODE	NE COUNT	DESTI-NATION λ	ELAPSED TIME	LONG ELAPSED PERIOD	WAITING FOR VACANCY
1	1	λ4	Add	3	Non	10	REACHED	WAITING
2	1	λ1	Add	2	Non	8	NOT-REACHED	NONE
3	1	λ5	Add	2	Non	3	NOT-REACHED	NONE
4	1	λ2	Add	2	Non	2	NOT-REACHED	NONE
-	-	-	-	-	-	-	-	-

【NE#2】 OPTICAL WAVE-LENGTH PATH MANAGEMENT INFORMATION

3505 3504

OPTICAL PATH ID	DIREC-TION	WAVE-LENGTH	MODE	NE COUNT	DESTI-NATION λ	ELAPSED TIME	LONG ELAPSED PERIOD	WAITING FOR VACANCY
1	1	λ4	Thru	3	Non	0	REACHED	WAITING
2	2	λ4	Thru	3	Non	0	REACHED	WAITING
3	2	λ1	Add	2	Non	9	NOT-REACHED	NONE
4	1	λ1	Drop	2	Non	0	NOT-REACHED	NONE
5	2	λ3	Add	2	Non	5	NOT-REACHED	NONE
6	1	λ5	Drop	2	Non	0	NOT-REACHED	NONE
7	2	λ5	Add	2	Non	3	NOT-REACHED	NONE
8	1	λ2	Drop	2	Non	0	NOT-REACHED	NONE
9	2	λ6	Add	2	Non	2	NOT-REACHED	NONE
-	-	-	-	-	-	-	-	-

【NE#3】 OPTICAL WAVE-LENGTH PATH MANAGEMENT INFORMATION

OPTICAL PATH ID	DIREC-TION	WAVE-LENGTH	MODE	NE COUNT	DESTI-NATION λ	ELAPSED TIME	LONG ELAPSED PERIOD	WAITING FOR VACANCY
1	1	λ4	Drop	3	Non	0	NOT-REACHED	NONE
2	1	λ1	Drop	2	Non	0	NOT-REACHED	NONE
3	1	λ3	Drop	2	Non	0	NOT-REACHED	NONE
4	1	λ5	Drop	2	Non	0	NOT-REACHED	NONE
5	1	λ2	Drop	2	Non	0	NOT-REACHED	NONE
6	1	λ6	Drop	2	Non	0	NOT-REACHED	NONE
-	-	-	-	-	-	-	-	-

AT START OF SUSPENSION CANCELATION

FIG.35AC

210

【NE#1】 OPTICAL WAVE-LENGTH PATH MANAGEMENT INFORMATION

3508

OPTICAL PATH ID	DIREC-TION	WAVE-LENGTH	MODE	NE COUNT	DESTI-NATION λ	ELAPSED TIME	LONG ELAPSED PERIOD	WAITING FOR VACANCY
1	1	λ4	Add	3	Non	10	REACHED	WAITING
2	1	λ1	Add	2	Non	8	NOT-REACHED	NONE
3	1	λ5	Add	2	Non	3	NOT-REACHED	NONE
4	1	λ2	Add	2	Non	2	NOT-REACHED	NONE
-	-	-	-	-	-	-	-	-

【NE#2】 OPTICAL WAVE-LENGTH PATH MANAGEMENT INFORMATION

OPTICAL PATH ID	DIREC-TION	WAVE-LENGTH	MODE	NE COUNT	DESTI-NATION λ	ELAPSED TIME	LONG ELAPSED PERIOD	WAITING FOR VACANCY
1	1	λ4	Thru	3	Non	0	REACHED	WAITING
2	2	λ4	Thru	3	Non	0	REACHED	WAITING
3	2	λ1	Add	2	Non	9	NOT-REACHED	NONE
4	1	λ1	Drop	2	Non	0	NOT-REACHED	NONE
5	~~2~~	~~λ3~~	~~Add~~	~~2~~	~~Non~~	~~5~~	~~NOT-REACHED~~	~~NONE~~
6	1	λ5	Drop	2	Non	0	NOT-REACHED	NONE
7	2	λ5	Add	2	Non	3	NOT-REACHED	NONE
8	1	λ2	Drop	2	Non	0	NOT-REACHED	NONE
9	2	λ6	Add	2	Non	2	NOT-REACHED	NONE
-	-	-	-	-	-	-	-	-

【NE#3】 OPTICAL WAVE-LENGTH PATH MANAGEMENT INFORMATION

OPTICAL PATH ID	DIREC-TION	WAVE-LENGTH	MODE	NE COUNT	DESTI-NATION λ	ELAPSED TIME	LONG ELAPSED PERIOD	WAITING FOR VACANCY
1	1	λ4	Drop	3	Non	0	NOT-REACHED	NONE
2	1	λ1	Drop	2	Non	0	NOT-REACHED	NONE
3	~~1~~	~~λ3~~	~~Drop~~	~~2~~	~~Non~~	~~0~~	~~NOT-REACHED~~	~~NONE~~
4	1	λ5	Drop	2	Non	0	NOT-REACHED	NONE
5	1	λ2	Drop	2	Non	0	NOT-REACHED	NONE
6	1	λ6	Drop	2	Non	0	NOT-REACHED	NONE
-	-	-	-	-	-	-	-	-

FIG.35BD

AT SUSPENSION CANCELATION REQUEST

210

3510 3511

[NE#1] OPTICAL WAVE-LENGTH PATH MANAGEMENT INFORMATION

OPTICAL PATH ID	DIREC-TION	WAVE-LENGTH	MODE	NE COUNT	DESTINATION λ	ELAPSED TIME	LONG ELAPSED PERIOD	WAITING FOR VACANCY
1	1	λ4	Add	3	λ3	10	REACHED	NONE
2	1	λ1	Add	2	Non	8	NOT-REACHED	NONE
3	1	λ5	Add	2	Non	3	NOT-REACHED	NONE
4	1	λ2	Add	2	Non	2	NOT-REACHED	NONE
-	-	-	-	-	-	-	-	-

[NE#2] OPTICAL WAVE-LENGTH PATH MANAGEMENT INFORMATION

OPTICAL PATH ID	DIREC-TION	WAVE-LENGTH	MODE	NE COUNT	DESTINATION λ	ELAPSED TIME	LONG ELAPSED PERIOD	WAITING FOR VACANCY
1	1	λ4	Thru	3	λ3	0	REACHED	WAITING
2	2	λ4	Thru	3	Non	0	REACHED	WAITING
3	2	λ1	Add	2	Non	9	NOT-REACHED	NONE
4	1	λ1	Drop	2	Non	0	NOT-REACHED	NONE
5	~~2~~	~~λ3~~	~~Add~~	~~2~~	~~Non~~	~~5~~	~~NOT-REACHED~~	~~NONE~~
6	1	λ5	Drop	2	Non	0	NOT-REACHED	NONE
7	2	λ5	Add	2	Non	3	NOT-REACHED	NONE
8	1	λ2	Drop	2	Non	0	NOT-REACHED	NONE
9	2	λ6	Add	2	Non	2	NOT-REACHED	NONE
-	-	-	-	-	-	-	-	-

[NE#3] OPTICAL WAVE-LENGTH PATH MANAGEMENT INFORMATION

OPTICAL PATH ID	DIREC-TION	WAVE-LENGTH	MODE	NE COUNT	DESTINATION λ	ELAPSED TIME	LONG ELAPSED PERIOD	WAITING FOR VACANCY
1	1	λ4	Drop	3	Non	0	NOT-REACHED	NONE
2	1	λ1	Drop	2	Non	0	NOT-REACHED	NONE
3	~~1~~	~~λ3~~	~~Drop~~	~~2~~	~~Non~~	~~8~~	~~NOT-REACHED~~	~~NONE~~
4	1	λ5	Drop	2	Non	0	NOT-REACHED	NONE
5	1	λ2	Drop	2	Non	0	NOT-REACHED	NONE
6	1	λ6	Drop	2	Non	0	NOT-REACHED	NONE
-	-	-	-	-	-	-	-	-

AT END OF SUSPENSION CANCELATION

FIG.35BE

210

【NE#1】 OPTICAL WAVE-LENGTH PATH MANAGEMENT INFORMATION

OPTICAL PATH ID	DIREC-TION	WAVE-LENGTH	MODE	NE COUNT	DESTI-NATION λ	ELAPSED TIME	LONG ELAPSED PERIOD	WAITING FOR VACANCY
1	1	λ4	Add	3	λ3	10	REACHED	NONE
2	1	λ1	Add	2	Non	8	NOT-REACHED	NONE
3	1	λ5	Add	2	Non	3	NOT-REACHED	NONE
4	1	λ2	Add	2	Non	2	NOT-REACHED	NONE
-	-	-	-	-	-	-	-	-

【NE#2】 OPTICAL WAVE-LENGTH PATH MANAGEMENT INFORMATION 3512 3513

OPTICAL PATH ID	DIREC-TION	WAVE-LENGTH	MODE	NE COUNT	DESTI-NATION λ	ELAPSED TIME	LONG ELAPSED PERIOD	WAITING FOR VACANCY
1	1	λ4	Thru	3	λ3	0	REACHED	NONE
2	2	λ4	Thru	3	λ3	0	REACHED	NONE
3	2	λ1	Add	2	Non	9	NOT-REACHED	NONE
4	1	λ1	Drop	2	Non	0	NOT-REACHED	NONE
5	~~2~~	~~λ3~~	~~Add~~	~~2~~	~~Non~~	~~5~~	~~NOT-REACHED~~	~~NONE~~
6	1	λ5	Drop	2	Non	0	NOT-REACHED	NONE
7	2	λ5	Add	2	Non	3	NOT-REACHED	NONE
8	1	λ2	Drop	2	Non	0	NOT-REACHED	NONE
9	2	λ6	Add	2	Non	2	NOT-REACHED	NONE
-	-	-	-	-	-	-	-	-

【NE#3】 OPTICAL WAVE-LENGTH PATH MANAGEMENT INFORMATION

OPTICAL PATH ID	DIREC-TION	WAVE-LENGTH	MODE	NE COUNT	DESTI-NATION λ	ELAPSED TIME	LONG ELAPSED PERIOD	WAITING FOR VACANCY
1	1	λ4	Drop	3	Non	0	NOT-REACHED	NONE
2	1	λ1	Drop	2	Non	0	NOT-REACHED	NONE
3	~~1~~	~~λ3~~	~~Drop~~	~~2~~	~~Non~~	~~0~~	~~NOT-REACHED~~	~~NONE~~
4	1	λ5	Drop	2	Non	0	NOT-REACHED	NONE
5	1	λ2	Drop	2	Non	0	NOT-REACHED	NONE
6	1	λ6	Drop	2	Non	0	NOT-REACHED	NONE
-	-	-	-	-	-	-	-	-

FIG.35BF

AT COMPLETION OF MOVEMENT FOR OPTIMIZATION

210

[NE#1] OPTICAL WAVE-LENGTH PATH MANAGEMENT INFORMATION

OPTICAL PATH ID	DIREC-TION	WAVE-LENGTH	MODE	NE COUNT	DESTI-NATION λ	ELAPSED TIME	LONG ELAPSED PERIOD	WAITING FOR VACANCY
1	1	λ4	Add	3	Non	10	REACHED	NONE
2	1	λ1	Add	2	Non	8	NOT-REACHED	NONE
3	1	λ5	Add	2	Non	3	NOT-REACHED	NONE
4	1	λ2	Add	2	Non	2	NOT-REACHED	NONE
-	-	-	-	-	-	-	-	-

[NE#2] OPTICAL WAVE-LENGTH PATH MANAGEMENT INFORMATION

OPTICAL PATH ID	DIREC-TION	WAVE-LENGTH	MODE	NE COUNT	DESTI-NATION λ	ELAPSED TIME	LONG ELAPSED PERIOD	WAITING FOR VACANCY
1	1	λ3	Thru	3	Non	0	REACHED	NONE
2	2	λ3	Thru	3	Non	0	REACHED	NONE
3	2	λ1	Add	2	Non	9	NOT-REACHED	NONE
4	1	λ1	Drop	2	Non	0	NOT-REACHED	NONE
5	~~2~~	~~λ3~~	~~Add~~	~~2~~	~~Non~~	~~5~~	~~NOT-REACHED~~	~~NONE~~
6	1	λ5	Drop	2	Non	0	NOT-REACHED	NONE
7	2	λ5	Add	2	Non	3	NOT-REACHED	NONE
8	1	λ2	Drop	2	Non	0	NOT-REACHED	NONE
9	2	λ6	Add	2	Non	2	NOT-REACHED	NONE
-	-	-	-	-	-	-	-	-

[NE#3] OPTICAL WAVE-LENGTH PATH MANAGEMENT INFORMATION

3514

OPTICAL PATH ID	DIREC-TION	WAVE-LENGTH	MODE	NE COUNT	DESTI-NATION λ	ELAPSED TIME	LONG ELAPSED PERIOD	WAITING FOR VACANCY
1	1	λ3	Drop	3	Non	0	REACHED	NONE
2	1	λ1	Drop	2	Non	0	NOT-REACHED	NONE
3	~~1~~	~~λ3~~	~~Drop~~	~~2~~	~~Non~~	~~0~~	~~NOT-REACHED~~	~~NONE~~
4	1	λ5	Drop	2	Non	0	NOT-REACHED	NONE
5	1	λ2	Drop	2	Non	0	NOT-REACHED	NONE
6	1	λ6	Drop	2	Non	0	NOT-REACHED	NONE
-	-	-	-	-	-	-	-	-

OPTICAL WAVELENGTH PATH REARRANGING METHOD, COMPUTER PRODUCT, OPTICAL TRANSMISSION MANAGING APPARATUS, AND OPTICAL TRANSMISSION APPARATUS

CROSS REFERENCE TO RELATED APPLICATIONS

This application is based upon and claims the benefit of priority of the prior Japanese Patent Application No. 2013-065273, filed on Mar. 26, 2013, the entire contents of which are incorporated herein by reference.

FIELD

The embodiments discussed herein are related to an optical wavelength path rearranging method, a computer product, an optical transmission managing apparatus, and an optical transmission apparatus that rearrange optical wavelengths of optical wavelength paths.

BACKGROUND

Wavelength division multiplexing (WDM) enables high-speed, large-capacity information communication by carrying optical signals of different optical wavelengths through one optical cable at the same time. A WDM network has multiple optical transmission apparatuses (NEs: Network Elements) such as optical cross-connects (OXCs) connected to each other through communication lines, forming a network of various shapes such as linear shapes, meshes, and rings.

While communication capacity can be expanded by employing a communication mode according to WDM, diversification of services using communication lines causes the utilization states of the communication lines to frequently change. Consequent to a greater volume of data, one service may occupy a larger proportion of the communication routes. In such a situation, to ensure necessary communication routes, multiple optical wavelength paths between optical transmission apparatuses must be set individually without crossing (interference) one another.

Currently, when communication routes are optimized, a maintenance person predicts line utilization states when providing servicing and sets optimal optical wavelength paths. However, if the utilization state is different from the prediction, a central monitoring system (OpS) that manages the network moves optical wavelengths in units of optical wavelength paths.

If optical wavelength paths set in WDM signals are randomly and repeatedly set and deleted, fragmentation of the optical wavelength paths occurs in communication routes. The occurrence of the fragmentation in optical wavelengths makes it difficult to set an optical wavelength path having the same optical wavelength between multiple NEs (long path), reducing usage efficiency of WDM lines.

To avoid such fragmentation, techniques of optimizing the setting of optical wavelength paths have been disclosed (see, e.g., Japanese Laid-Open Patent Publication Nos. 2012-109928 and 2012-195787). In the technique of Japanese Laid-Open Patent Publication No. 2012-109928, the number of used optical wavelength regions is made smaller than that before rearrangement and an available optical wavelength is utilized to change an optical wavelength path to another optical wavelength path. In the technique of Japanese Laid-Open Patent Publication No. 2012-195787, optical wavelengths are rearranged such that optical signals of the same modulation mode become adjacent to one another so as to reduce the number of guard bands having a specific optical wavelength interval on the side portions of the optical signals, thereby increasing the band utilization rate.

However, when the setting of optical wavelength paths is optimized, if the communication routes of the optical wavelength paths are intricately routed in a network of increased scale, rearrangement of the optical wavelength paths without affecting other services is difficult and requires complicated control for execution and high cost for maintenance.

Particularly, no proposal has been made on a method of managing which optical wavelength path is to be rearranged (optimized) or on a technique of efficiently providing control necessary for actual rearrangement (e.g., the number of times an optical wavelength path is moved to a different optical wavelength).

SUMMARY

According to an aspect of an embodiment, an optical wavelength path rearranging method includes detecting time that elapses since a setting of optical wavelength paths in an optical wavelength division multiplexing network; and moving to a predetermined long-period optical wavelength range, an optical wavelength path that is among the optical wavelength paths and for which the detected elapsed time is long, where the optical wavelength path rearranging method is executed by a processor.

The object and advantages of the invention will be realized and attained by means of the elements and combinations particularly pointed out in the claims.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are not restrictive of the invention.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a diagram for explaining optimization of optical wavelength paths according to an embodiment;

FIG. **2** is a functional block diagram for controlling optimization of the optical wavelength paths;

FIG. **3** is a chart of a data configuration of optical wavelength path management information;

FIG. **4** is a diagram of a network configuration for implementing optimization of optical wavelength paths according to a first embodiment;

FIG. **5** is a block diagram of functions of an optical transmission managing apparatus and an optical transmission apparatus according to the first embodiment;

FIG. **6** is a block diagram of a hardware configuration of the optical transmission managing apparatus and the optical transmission apparatus according to the first embodiment;

FIG. **7** is a chart of an example of a format of a message supplied from an OpS to an NE according to the first embodiment;

FIG. **8** is a flowchart of a process of determining a long-elapsed-period optical wavelength path according to the first embodiment;

FIG. **9** is a flowchart of a process of starting optical wavelength path movement according to the first embodiment;

FIG. **10** is a flowchart of a process for an optical wavelength path movement request from the OpS to the NE according to the first embodiment;

FIG. **11** is a flowchart of optical wavelength path movement control at the NE according to the first embodiment;

FIG. **12** is a sequence diagram of optical wavelength path movement through message transmission/reception between the OpS and the NE according to the first embodiment;

FIG. **13** is a diagram of a state in which a predetermined optical wavelength path is moved according to the first embodiment;

FIGS. **14**A and **14**B are charts of settings in the optical wavelength path management information at the time of movement of the optical wavelength path according to the first embodiment;

FIG. **15** is a sequence diagram of movement after suspension of an optical wavelength path according to the first embodiment;

FIG. **16** is a diagram of a state of movement after movement suspension of the optical wavelength path according to the first embodiment;

FIGS. **17**A, **17**B, and **17**C are charts of settings in the optical wavelength path management information that includes optical wavelength path suspension according to the first embodiment;

FIG. **18** is a diagram of a network configuration for implementing optimization of optical wavelength paths according to a second embodiment;

FIG. **19** is a block diagram of functions of the optical transmission apparatus according to the second embodiment;

FIG. **20** is a block diagram of a hardware configuration example of the optical transmission apparatus according to the second embodiment;

FIGS. **21**A and **21**B are charts of an example of a format of a message between NEs according to the second embodiment;

FIG. **22** is a flowchart of a process of determining a long-elapsed-period optical wavelength path according to the second embodiment;

FIG. **23** is a flowchart of a process of determining whether an optical wavelength path can be moved according to the second embodiment;

FIG. **24** is a flowchart of a process of requesting optical wavelength path movement, by message reception from an adjacent NE according to the second embodiment;

FIG. **25** is a flowchart of a process of determining whether movement is possible at a given NE and transferring a movement request to another NE based on a request for optical wavelength path movement according to the second embodiment;

FIG. **26** is a flowchart of a movement process based on a request for optical wavelength path movement according to the second embodiment;

FIG. **27** is a flowchart of a process of determining optical wavelength movement based on reception of a movement response for an optical wavelength path;

FIG. **28** is a flowchart of a process associated with deletion of an optical wavelength set as a long-term-setting-path according to the second embodiment;

FIG. **29** is a flowchart of a process of resuming movement of an optical wavelength path based on notification of path block cancellation according to the second embodiment;

FIG. **30** is a sequence diagram of optical wavelength path movement through message transmission/reception between the NEs according to the second embodiment;

FIG. **31** is a diagram of a state in which a predetermined optical wavelength path is moved according to the second embodiment;

FIGS. **32**A, **32**B, and **32**C are charts of settings in the optical wavelength path management information at the time of movement of the optical wavelength path according to the second embodiment;

FIG. **33** is a sequence diagram of movement after suspension of an optical wavelength path according to the second embodiment;

FIG. **34** is a diagram of a state of movement after movement suspension of the optical wavelength path according to the second embodiment; and

FIGS. **35**AA, **35**AB, **35**AC, **35**BD, **35**BE, and **35**BF are charts of setting details in the optical wavelength path management information including suspension of the optical wavelength path according to the second embodiment.

DESCRIPTION OF EMBODIMENTS

Embodiments will be described in detail with reference to the accompanying drawings. FIG. **1** is a diagram for explaining optimization of optical wavelength paths according to an embodiment. Each optical transmission apparatus (NEs #1 to #4) **101** transmits optical signals of optical wavelengths λ1 to λ10. In FIG. **1**, a block circle mark (●) denotes a termination (insertion or branch point) of an optical wavelength path **100**. An optical wavelength path **100** passing through an optical transmission apparatus **101** (e.g., an optical wavelength path passing through NE #2 of the wavelength λ2) allows passage (Thru) of an optical signal through the optical transmission apparatus **101** (NE #2). Each of the optical transmission apparatuses **101** (NEs #1 to #4) has a function of changing an optical wavelength of an optical signal to λ1 to λ10 and can change an optical wavelength of an optical wavelength path at the time of movement of the optical wavelength.

In the embodiment, the time that elapses since the setting of an optical wavelength path is managed for each optical wavelength path. The time that elapses since the setting of an optical wavelength path is measured, and an optical wavelength path (long-elapsed-period optical wavelength path) having an elapsed time that is longer than a predetermined constant period (long-setup elapsed time) is targeted for optical wavelength path optimization.

If an available optical wavelength is among long-term-setting-paths **100**A of an optical wavelength range defined in advance for a long-setup path (in the example of FIG. **1**, four long-term-setting-paths, including the optical wavelengths λ1 to λ4), the long-elapsed-period optical wavelength path is moved to this optical wavelength. In the example of FIG. **1**, three optical wavelength paths **100***b* corresponding to the long-elapsed-period optical wavelength paths are moved to the long-term-setting-paths **100**A. The determination of the movement is made by checking information concerning the optical wavelengths of the optical wavelength paths **100***b* and transmission sections of the optical wavelength paths against information concerning the available optical wavelengths of the long-term-setting-paths **100**A and the transmission sections to determine whether the optical wavelength paths can be accommodated (moved).

Although the long-term-setting-paths **100**A are brought together on the shorter wavelength side λ1 to λ4 in the example of FIG. **1**, the optical wavelengths not only may be brought together on the shorter wavelengths but may be brought together on the longer wavelength side or dispersed to different wavelengths as long as the wavelengths are fixed in advance.

On the other hand, if the long-term-setting-path **100**A is not available, the movement of the long-elapsed-period optical wavelength path to be moved is suspended until the long-term-setting-path **100**A becomes available for the movement. The long-elapsed-period optical wavelength path retains information indicating that movement has been suspended. The long-elapsed-period optical wavelength path for which movement has been suspended is subsequently moved if a long-term-setting-path **100**A becomes available. For example, a long-elapsed-period optical wavelength path **100***c* of the optical wavelength λ5 in the transmission section between NE #2 and NE #4 in FIG. **1** can be moved to the optical wavelength λ4 after deletion of an optical wavelength path of the optical wavelength λ4 in the transmission section between NE #3 and NE #4. Corresponding to the transmission sections to which the optical wavelength are moved, the optical transmission apparatuses **101** (NEs #1 to #4) change the wavelengths (Add/Thru/Drop) for transmission signals, to the post-movement wavelengths.

According to the optimization of the optical wavelength paths, the long-staying optical wavelength paths **100***b* are brought together to the predetermined optical wavelengths (long-term-setting-paths **100**A) to prevent dispersion. As a result, optical wavelength paths that change in a short period of time can be handled by more optical wavelengths among the optical wavelengths excluding the long-term-setting-paths **100**A (in the example of FIG. **1**, the six optical wavelengths including the optical wavelengths λ5 to λ10). In FIG. **1**, the optical wavelengths λ5 to λ10 are depicted as newly-set-path optical wavelengths **100**B. The settable number of short-period optical wavelength paths that can be set to the newly-set-path optical wavelengths **100**B increases and as a result, the usage efficiency of the optical wavelengths overall (λ1 to λ10 and the optical wavelengths λ1 to λ10 between NEs) can be increased.

Since the optical wavelength paths **100***b* having a relatively longer setup period are preferentially allocated to the predetermined optical wavelengths (long-term-setting-paths **100**A), the number of times of movement is performed (changes in optical wavelength) for optimization can be reduced and improved quality can be achieved in signals during communication service. For example, in the example depicted in FIG. **1**, optimization of the optical wavelength paths enables the setting of new optical wavelength paths **100** having a long path across all the optical transmission apparatuses **101** from NE #1 to NE #4 at the optical wavelengths λ5 and λ10 among the newly-set-path optical wavelengths **100**B. At the optical wavelengths λ8 and λ9, new optical wavelength paths **100** can be set across multiple optical transmission apparatuses **101** (NEs).

FIG. **2** is a functional block diagram for controlling optimization of the optical wavelength paths. As described later, the control for optimizing optical wavelength paths can be provided through central control by an optical transmission managing apparatus such as an OpS or management by the optical transmission apparatuses (NEs #1 to #4). The functions depicted in FIG. **2** can be disposed in the optical transmission managing apparatus or the optical transmission apparatuses.

As depicted in FIG. **2**, an optimization control unit **200** includes an optical wavelength path setting unit **201**, an elapsed time monitoring unit (time monitoring unit) **202**, an optical wavelength path moving unit (movement control unit) **203**, and a suspended path moving unit (suspension control unit) **204**.

If the setting of an optical wavelength path is changed, the optical wavelength path setting unit **201** updates the corresponding optical wavelength information in optical wavelength path management information **210**. Setting related to the optical wavelength paths is set in an OpS **401** or is collected by the OpS **401** through communication with the optical transmission apparatuses (NEs #1 to #4) 101 and retained as a table consolidated by the OpS **401**.

The elapsed time monitoring unit **202** regularly refers to a path setup elapsed time in the optical wavelength path management information **210** to monitor whether the path setup elapsed time exceeds a value of long-period threshold information **211** (long-setup elapsed time) and set for the time in advance. The elapsed time monitoring unit **202** sets an optical wavelength path that exceeds the threshold value, as a long-elapsed-period optical wavelength path. The elapsed time monitoring unit **202** transmits a message to the optical wavelength path moving unit **203** for the optical wavelength path optimization, causing the optical wavelength path moving unit **203** to execute a process.

In response to the notification of the optical wavelength path defined as the long-elapsed-period optical wavelength path, the optical wavelength path moving unit **203** determines movement to achieve optimization. The optical wavelength path moving unit **203** checks whether an optical wavelength (movement destination) is available at an optical transmission apparatus (NE) on the route of the optical wavelength path to be moved. If available, the optical wavelength path is moved. If not available, the optical wavelength path is not moved and the suspension of the movement is recorded in the optical wavelength path management information **210**.

If an optical wavelength path set in the long-term-setting-path **100**A is deleted, the suspended path moving unit **204** manages the suspension of the optical wavelength path. The suspended path moving unit **204** detects a vacancy for the long-elapsed-period optical wavelength path of the suspended movement and requests the optical wavelength path moving unit **203** to move the suspended long-elapsed-period optical wavelength path when a vacancy occurs.

FIG. **3** is a chart of a data configuration of optical wavelength path management information. The optical wavelength path management information **210** has parameters set as "optical wavelength path ID", "optical wavelength path route information", "elapsed time", "long elapsed period", and "waiting for vacancy". The "optical wavelength path ID" is an ID specified when a maintenance person manages an optical wavelength path. The "optical wavelength path route information" is information for determining a route of a set optical wavelength path and the necessary information is different between the optical transmission managing apparatus (OpS) and the optical transmission apparatus (NE). The following information is retained: OpS: optical wavelength, insertion node ID (Add Node ID), passage node ID (Thru Node ID (1 . . . n)), and branch node ID (Drop Node ID); and NE: directional path, optical wavelength, mode (Add/Drop/Thru), route NE number, and movement destination optical wavelength (λ).

The "elapsed time" is information that indicates the elapsed time since the setting of an optical wavelength path and is for determining whether the optical wavelength path is a path set for a long period. If path setting is "Add", time monitoring is performed. In the case of "Thru" or "Drop", time monitoring is not performed and therefore, the initial value (0) does not change. The "long elapsed period" is updated if it is determined that an optical wavelength path has been continuously set for a long period. If the path setting is "Thru" or "Drop", the "long elapsed period" is set in conjunction with the optical transmission apparatus (Add NE) at an insertion position on the route. The setting values are as follows: "not-reached": a value indicative of a case of less than a given period (initial value); and "reached": a value indicative of a case of equal to or greater than the given period.

The "waiting for vacancy" indicates that the movement for achieving optimization has been suspended due to the absence of a vacancy for a long-elapsed-period optical wavelength path at the movement destination when an optical wavelength path is to be moved for optimization. The setting values are as follows:

"none": a value indicative of the absence of suspended movement (initial value); and

"suspended": a value indicative of the presence of suspended movement.

FIG. **4** is a diagram of a network configuration for implementing optimization of optical wavelength paths according to a first embodiment. The first embodiment will be described in terms of the optimization of optical wavelength paths in a WDM network by an OpS.

As depicted in FIG. **4**, three NEs (#1 to #3) **101** are connected through a WDM line **402** in a linear configuration. Each of the NEs **101** has an optical cross-connecting unit (OXC) **410** and multiplexes and transmits to another NE **101**, optical signals adjusted to optical wavelengths of the WDM. In FIG. **4**, a solid line indicates an optical wavelength path and optical wavelength path terminating apparatuses **411** terminate the optical wavelength paths. For example, the optical wavelength path of the optical wavelength λ1 is set between the NE #1 and the NE #2.

With regard to the optimization of optical wavelength paths, the optical transmission managing apparatus (OpS) **401** makes a determination and gives to the NEs **101**, instructions for movement of optical wavelength paths to achieve optimization. In FIG. **4**, dotted lines indicate control paths connecting the OpS **401** to the NEs **101**. The NEs **101** also exchange control information with one another by using a monitoring signal (Optical Supervisor Channel (OSC)) such as a wavelength different from a main signal (transmission signal).

FIG. **5** is a block diagram of functions of the optical transmission managing apparatus and the optical transmission apparatus according to the first embodiment. Among the functions depicted in FIG. **5**, functions identical to those depicted in FIG. **2** are denoted by the same reference numerals used in FIG. **2**. The control related to the optimization of the optical wavelength paths is entirely provided by the optical transmission managing apparatus (OpS) **401**. The OpS **401** has an NE communications unit **501** and the NE **101** has an OpS communications unit **510**. The OpS **401** instructs the NE **101** to move an optical wavelength path and the NE **101** moves the optical wavelength path.

FIG. **6** is a block diagram of a hardware configuration of the optical transmission managing apparatus and the optical transmission apparatus according to the first embodiment. The OpS **401** includes a central processing unit (CPU) **601** acting as a control unit, memory **602**, flash memory **603**, and a communications device **604**.

The CPU **601** provides control of managing optical transmission, based on a control program stored in the memory **602**, etc. and also provides control related to the optical wavelength path optimization. The flash memory **603** stores setting values (parameters) necessary for the optimization. The communications device **604** is made up of a communication I/F card, etc. and communicates with the NE **101**. The CPU **601** to the communications device **604** are connected through a bus **605**.

Functions of the optical wavelength path setting unit **201**, the elapsed time monitoring unit **202**, the optical wavelength path moving unit **203**, and the suspended path moving unit **204** depicted in FIG. **5** are obtained when the CPU **601** depicted in FIG. **6** executes the control program. The NE communications unit **501** depicted in FIG. **5** may be configured by the communications device **604** depicted in FIG. **6**.

The optical transmission device **101** includes a CPU **611**, memory **612**, flash memory **613**, a communications device **614**, a WDM signal terminating device **615**, an optical demultiplexing device **616**, an optical multiplexing device **617**, and an optical amplifying device **618**.

The CPU **611** provides control for optical transmission, based on a control program stored in the memory **612**, etc. Based on the control from the OpS **401**, the CPU **611** controls the movement, etc. of an optical wavelength path related to optical wavelength path optimization. The memory **612** and the flash memory **613** store setting values (the optical wavelength path management information **210**), etc. necessary at the time of movement of an optical wavelength path. The communications device **614** is made up of a communication I/F card, etc. and communicates with the OpS **401**.

The optical transmission apparatus **101** uses the WDM signal terminating device **615**, the optical demultiplexing device **616**, and the optical multiplexing device **617** to insert and branch the optical wavelength paths in the optical transmission apparatus **101** and, to set and move the optical wavelength paths. The optical amplifying device **618** optically amplifies an optical signal transmitted over long distance.

FIG. **7** is a chart of an example of a format of a message supplied from the OpS to the NE according to the first embodiment. Description will be made of an example of a message for optical wavelength path movement control from the OpS **401** to the NE **101** and for a response to the movement control from the NE **101**. A movement control message **701** includes a "message type", a "response type", a "movement object directional path", a "movement source optical wavelength", and a "movement destination optical wavelength". The "message type" is set to "request" or "response". The "response type" is set to "successful (OK)" or "failed (NG)" when the message type is "response". The "movement object directional path" is set to a directional path to which an optical wavelength path to be moved is set. The "movement source optical wavelength" is set to the optical wavelength λ of the optical wavelength path that is to be moved. The "movement destination optical wavelength" is set to the optical wavelength λ to which the optical path is to be moved.

An optical wavelength path optimization process according to the first embodiment will be described. FIG. **8** is a flowchart of a process of determining a long-elapsed-period optical wavelength path according to the first embodiment. A process executed by the elapsed time monitoring unit **202** of the OpS **401** by using a timer interrupt will be described.

The elapsed time monitoring unit **202** refers to the "long elapsed period" in the optical wavelength path management information **210** for each periodic timer interrupt of a constant period (step **S801**). If the "long elapsed period" indicates "not-reached" (step **S802**: not-reached), the process proceeds to step **S803** and in the case of "reached" (step **S802**: reached), the timer is restarted without performing processing.

At step **S803**, the elapsed time monitoring unit **202** increments the "elapsed time" in the optical wavelength path management information **210** (step **S803**) and performs a comparison to determine whether the elapsed time in the optical wavelength path management information **210** is greater than a value of the long-period threshold information **211** (long-setup elapsed time) (step **S804**). If the elapsed time in the optical wavelength path management information **210** is greater than a value of the long-period threshold information **211** (step **S805**: YES), the process proceeds to step **S806**, and if not (step **S805**: NO), the timer is restarted without performing processing.

At step S806, the elapsed time monitoring unit 202 sets the "long elapsed period" in the optical wavelength path management information 210 to "reached" (step S806), and requests the optical wavelength path moving unit 203 to move the long-elapsed-period optical wavelength path (step S807). The timer is then restarted.

FIG. 9 is a flowchart of a process of starting optical wavelength path movement according to the first embodiment. A process executed by the optical wavelength path moving unit 203 will be described. The optical wavelength path moving unit 203 of the OpS 401 receives from the elapsed time monitoring unit 202, a movement request for a long-elapsed-period optical wavelength path and executes the following process.

First, the optical wavelength path moving unit 203 checks whether a long-term-setting-path 100A is available in the same route as the optical wavelength path of the movement source (step S901). If a long-term-setting-path 100A is available (step S902: YES), the optical wavelength path moving unit 203 proceeds to step S903; and if not available (step S902: NO), the optical wavelength path moving unit 203 proceeds to step S905.

At step S903, the optical wavelength path moving unit 203 sets the optical wavelength of the movement destination as the optical wavelength in the optical wavelength path management information 210 (step S903) and requests the NE communications unit 501 to transmit a movement request message to all the NEs (NEs #1 to #3 of FIG. 4) 101 on the route of the optical wavelength path (step S904). The optical wavelength path moving unit 203 then waits for the next request.

At step S905, since it is determined that the optical wavelength path cannot be moved, the optical wavelength path moving unit 203 sets in the optical wavelength path management information 210, "waiting" in the "waiting for vacancy" for the optical wavelength to be moved (step S905) and waits for the next request.

FIG. 10 is a flowchart of a process for an optical wavelength path movement request from the OpS to the NE according to the first embodiment. A process executed by the NE communications unit 501 of the OpS 401 will be described. First, the NE communications unit 501 determines the NEs 101 that are to be controlled, from the optical wavelength path ID requested from the optical wavelength path moving unit 203 (step S1001). In this case, the NEs 101 to be controlled are determined by referring to the insertion (Add) node, the passage (Thru) nodes (1) . . . (n), and the branch (Drop) node of the optical wavelength path ID in the optical wavelength path management information 210. The NE communications unit 501 transmits a movement control message to the NEs that are to be controlled (step S1002) and waits for the next request.

FIG. 11 is a flowchart of optical wavelength path movement control at the NE according to the first embodiment. In response to the movement control message received by the OpS communications unit 510 of the NE 101, the NE 101 changes an optical wavelength via the optical cross-connecting unit 410 to move the optical wavelength path. In other words, in terms of the order of processing, when the OpS communications unit 510 of the NE 101 receives the movement control message from the OpS 401, the optical cross-connecting unit 410 moves the optical wavelength path of the movement source to the optical wavelength path of the movement destination (step S1101).

If the movement of the optical wavelength path is successful (step S1102: YES), the NE 101 proceeds to step S1103, and if not successful (step S1102: NO), the NE 101 proceeds to step S1104. At step S1103, a response concerning the movement control is set to "successful" and transmitted to the OpS 401 (step S1103). At step S1104, a response concerning the movement control is set to "failed" and transmitted to the OpS 401 (step S1104). After transmission at step S1103 or step S1104, the NE 101 waits for the next request.

FIG. 12 is a sequence diagram of optical wavelength path movement through message transmission/reception between the OpS and the NE according to the first embodiment. As depicted in FIG. 12, if a given optical wavelength path is determined as a long-elapsed-period optical wavelength path at the OpS 401 (step S1201), a movement request is transmitted to the NEs #1 to #3 (101) on the route of the optical wavelength path (step S1202). Each of the NEs #1 to #3 (101) on the route performs movement to the optical wavelength specified as the movement destination (step S1203). Each of the NEs #1 to #3 (101) transmits a result "successful/failed" concerning the movement of the optical wavelength as a response to the movement request to the OpS 401 (step S1204). Base on the responses, the OpS 401 updates the optical wavelength path management information 210 (step S1205).

FIG. 13 is a diagram of a state in which a predetermined optical wavelength path is moved according to the first embodiment. As depicted in FIG. 13, when the optical wavelength path of the optical wavelength λ4 (terminated by the NEs #1 and #3; the NE #2 is Thru) becomes a long-elapsed-period optical wavelength path and the optical wavelength λ3 among the long-term-setting-paths 100A is available, the optical wavelength path is moved by changing the optical wavelength from λ4 to λ3.

FIGS. 14A and 14B are charts of settings in the optical wavelength path management information at the time of movement of the optical wavelength path according to the first embodiment. FIGS. 14A and 14B depict settings in the optical wavelength path management information at the time of movement of the optical wavelength path depicted in FIG. 13. FIG. 14A depicts the optical wavelength path management information 210 at the time of start of movement of the optical wavelength path for optimization, while FIG. 14B depicts the optical wavelength path management information 210 at the time of completion of the movement.

At the start of the movement for optimization depicted in FIG. 14A, since an elapsed time 1401 for the optical wavelength path of the wavelength λ4 between the NEs #1 and #3 (101) has reached a threshold value ("10 hours" in the example of FIG. 14A) for the long elapsed time, the elapsed time monitoring unit 202 of the OpS 401 determines that this optical wavelength path is a long-elapsed-period optical wavelength path and sets a long elapsed period 1402 in the optical wavelength path management information 210 to "reached".

The optical wavelength path moving unit 203 searches for an available long-term-setting-path (λ1 to λ3), determines that the optical wavelength λ3 is available, and therefore, specifies the movement source optical wavelength as λ4 and the movement destination optical wavelength as λ3. The OpS 401 notifies each of the NE #1, the NE#2, and the NE #3 (101) of the movement control message through a message between the OpS 401 and the NEs #1, #2, and #3 (101).

Subsequently, as depicted in FIG. 14B, at the time of completion of the movement for optimization, when successful at switching the wavelength from λ4 to λ3, the NE #1, the NE#2, and the NE #3 (101) return "successful" to the OpS 401 as a response to the movement control. As a result, the OpS 401 receives "successful" as the response to the movement control and therefore, changes an optical wavelength

1403 of the optical wavelength path ID in the optical wavelength path management information 210 from the optical wavelength λ4 to the optical wavelength λ3, which is the movement destination.

FIG. 15 is a sequence diagram of movement after suspension of an optical wavelength path according to the first embodiment. If no movement destination exists for a long-elapsed-period optical wavelength path, the OpS 401 suspends the movement of the optical wavelength (step S1501).

The OpS 401 subsequently exchanges a movement control message 701 between the OpS 401 and the NE 101 to move the optical wavelength path in a synchronized manner. In this case, when a long-term-setting-path 100A becomes available, the OpS 401 resumes the control of the movement (step S1502). The OpS 401 transmits a movement request to the NEs #1 to #3 (101) on the route of the optical wavelength path (step S1503). Each of the NEs #1 to #3 (101) on the route performs movement to the optical wavelength specified as the movement destination (step S1504). Each of the NEs #1 to #3 (101) transmits to the OpS 401, a result "successful/failed" concerning the movement of the optical wavelength, as a response to the movement request (step S1505).

FIG. 16 is a diagram of a state of movement after movement suspension of the optical wavelength path according to the first embodiment. As depicted in FIG. 16 it is assumed that all the wavelengths λ1 to λ3 among the long-term-setting-paths 100A are being used and are unavailable. In this case, even when the optical wavelength path of the optical wavelength λ4 (terminated by the NEs #1 and #3; the NE #2 is Thru) becomes a long-elapsed-period optical wavelength path, movement to a long-term-setting-path 100A cannot be performed and the movement state is suspended.

It is assumed that a vacancy subsequently occurs because the optical wavelength path (terminated by the NEs #2 and #3) 100*d* of the optical wavelength λ3 among the long-term-setting-paths 100A is deleted. As a result, the suspended optical wavelength path of the optical wavelength λ4 can be moved to the wavelength λ3.

FIGS. 17A, 17B, and 17C are charts of settings in the optical wavelength path management information that includes optical wavelength path suspension according to the first embodiment. FIGS. 17A to 17C depict settings in the optical wavelength path management information from the suspension of, to the completion of the movement of the optical wavelength path depicted in FIG. 16. FIG. 17A depicts the optical wavelength path management information 210 at the start of suspension of the movement of the optical wavelength path for optimization; FIG. 17B depicts the optical wavelength path management information 210 at the time of cancellation of suspension of the movement of the optical wavelength path for optimization; and FIG. 17C depicts the optical wavelength path management information 210 at the time of completion of the movement.

As depicted in FIG. 17A, at the start of suspension of the movement for optimization, since an elapsed time 1701 for the optical wavelength path of the wavelength λ4 between the NEs #1 and #3 (101) reaches the threshold value (e.g., "10 hours"), the elapsed time monitoring unit 202 of the OpS 401 determines that this optical wavelength path is a long-elapsed-period optical wavelength path and sets a long elapsed period 1702 to "reached". However, after searching for an available long-term-setting-path (λ1 to λ3) between the NEs #1 and #3 (101), the optical wavelength path moving unit 203 determines that no vacancy exists and therefore, sets "waiting" in waiting for vacancy 1703 of λ4 in the optical wavelength path management information 210.

With regard to the cancellation of suspension of the movement for optimization depicted in FIG. 17B, it is assumed that the optical wavelength path of the optical wavelength λ3 between the NE #2 and the NE #3 is deleted as depicted in FIG. 16. To check for the presence of a suspended long-elapsed-period optical wavelength path, the suspended path moving unit 204 searches for "waiting" set in the waiting for vacancy. Since "waiting" is set in the waiting for vacancy 1703 for the optical wavelength λ4 (optical wavelength path ID=1) in the optical wavelength path management information, the optical wavelength path moving unit 203 confirms that the movement destination optical wavelength λ3 is available for the entire route of the movement source optical wavelength λ4 (optical wavelength path route information 1704). The optical wavelength path moving unit 203 then transmits to the NE #1, the NE #2, and the NE #3 (101), control for moving the optical wavelength path of the wavelength λ4 to the wavelength λ3. The NEs #1 to #3 receive this instruction and move the wavelength λ4 to the wavelength λ3.

As depicted in FIG. 17C, at the time of completion of the movement for optimization, if successful at switching the wavelength λ4 to the wavelength λ3, the NEs #1 to #3 (101) return "successful" to the OpS 401 as a response to the movement request. The OpS 401 receives "successful" as a response to the movement request and therefore, in the optical wavelength path management information 210, changes an optical wavelength 1705 in the information from the wavelength λ4 (optical wavelength path ID=1) to the optical wavelength λ3, which is the movement destination.

According to the first embodiment described above, based on the elapsed time of the optical wavelength paths of the optical transmission apparatuses 101 on the transmission path, the OpS 401 performs the optical wavelength movement of a long-elapsed-period optical wavelength path having the long elapsed time to a long-term-setting-path 100A within the predetermined optical wavelength range. Even if the long-elapsed-period optical wavelength path having a long elapsed time cannot be moved immediately, the movement-suspended state is maintained and the movement is performed as soon as a corresponding optical wavelength becomes available. As a result, the OpS 401 can centrally manage the optical transmission apparatuses 101 and bring the long-elapsed-period optical wavelength paths used for a long period together in the predetermined long-term-setting-paths 100A to prevent dispersion, thereby eliminating the fragmentation of the unused areas of the optical wavelength paths in WDM transmission using multiple wavelengths.

FIG. 18 is a diagram of a network configuration for implementing optimization of optical wavelength paths according to a second embodiment. The second embodiment will be described in terms of the optimization of optical wavelength paths in a WDM network by the NE. In the second embodiment, the OpS does not control the optimization of optical wavelength paths and the NE 101 autonomously controls the optimization of optical wavelength paths.

As depicted in FIG. 18, three NEs (#1 to #3) 101 are connected through a WDM line 402 in a linear configuration. Each of the NEs 101 has an optical cross-connecting unit (OXC) 410 and multiplexes and transmits to another NE 101, optical signals adjusted to optical wavelengths of WDM. In FIG. 18, a solid line indicates an optical wavelength path and optical wavelength path terminating apparatuses 411 terminate the optical wavelength paths. For example, the optical wavelength path of the optical wavelength λ1 is set between the NE #1 and the NE #2.

For the optimization of optical wavelength paths, each of the optical transmission apparatuses (NEs) 101 moves the optical wavelength paths in synchronization with the other NEs **101** in the WDM network. The NEs #1 to #3 (**101**) use a monitoring signal OSC for control information when controlling the optical wavelength paths in a synchronized manner.

FIG. **19** is a block diagram of functions of the optical transmission apparatus according to the second embodiment. Among the functions of FIG. **19**, functions identical to those depicted in FIG. **2** are denoted by the same reference numerals used in FIG. **2**. The control related to the optimization of the optical wavelength paths depicted in FIG. **2** is provided entirely by the optical transmission apparatus (NE) **101**.

In addition to the functions depicted in FIG. **2**, this NE **101** has a start-up unit **1901** that confirms consistency with the other NEs **101** in the WDM network at the start-up of the NE **101**. The NE **101** also includes an optical wavelength path movement preparing unit **1902** that prepares movement of an optical wavelength path by referring to the optical wavelength path management information **210** at the time of a movement request for the optical wavelength path, an inter-NE message transmitting unit **1903** that transmits messages to the other NEs **101**, an inter-NE message receiving unit **1904** that receives messages from the other NEs **101**, and a WDM monitoring control unit **1905** for exchanging messages by using OSCs with the other NEs **101**, etc.

FIG. **20** is a block diagram of a hardware configuration example of the optical transmission apparatus according to the second embodiment. As is the case with the NE **101** depicted in FIG. **6**, the NE **101** includes the CPU **611**, the memory **612**, the flash memory **613**, the WDM signal terminating device **615**, the optical demultiplexing device **616**, the optical multiplexing device **617**, and the optical amplifying device **618**. In the second embodiment, the NE **101** additionally includes an OSC signal terminating device **2001** that transmits/receives control information (OSC signal) for synchronizing the movement of an optical wavelength path between NEs **101**.

FIGS. **21**A and **21**B are charts of an example of a format of a message between the NEs according to the second embodiment. FIGS. **21**A and **21**B depict a movement request message exchanged for synchronization among the NEs **101** in the WDM network when a long-elapsed-period optical wavelength path is moved.

As depicted in FIG. **21**A, a message format of a movement request (and a movement response to the movement request) **2101** includes a "message type", a "detailed type", a "parameter 1", and a "parameter 2". As depicted in FIG. **21**B, the "message type" is set to either "path movement" or "path block cancellation". If the "message type" is "path movement", the NE **101** of the movement request transmission source sets the "detailed type" to "request". The NE **101** terminating an optical wavelength path set as the movement source optical wavelength sets the "detailed type" to "response" to send a response to the NE **101** that is the transmission source of the request. The NE **101** in the middle of the route of the optical wavelength path set as the movement source optical wavelength sets the "detailed type" to "response" if no movement destination optical wavelength is available, and sends a response to the NE **101** that is the transmission source of the request.

The "parameter 2" of the "response" is set as a determination result of the optical wavelength movement in the NE **101** relaying or terminating the optical wavelength path of the movement source optical wavelength, and is set to "OK" if a movement destination wavelength is available and to "NG" if no movement destination wavelength is available. The movement source optical wavelength (λ) of the "parameter 1" is set to a long-setup optical wavelength that is to be moved by the movement request transmission source NE **101**. The movement destination optical wavelength (λ) of the "parameter 2" is set to a long-term-setting-path that is a movement destination at the movement request transmission source NE **101**.

At the time of the "path block cancellation", the "detailed type" is set to "notification" and the "parameter 1" is set to the optical wavelength (λ) to be released.

A process for optical wavelength path optimization according to the second embodiment will be described. FIG. **22** is a flowchart of a process of determining a long-elapsed-period optical wavelength path according to the second embodiment. A process executed by the elapsed time monitoring unit **202** of the NE **101** by using a timer interrupt will be described. The elapsed time monitoring unit **202** refers to the "long elapsed period" in the optical wavelength path management information **210** (see FIG. **3**) for each periodic timer interrupt of a constant period (step S**2201**). The elapsed time monitoring unit **202** determines whether the "long elapsed period" already indicates that the long elapsed period has been reached (step S**2202**). If the "long elapsed period" has not been reached (step S**2202**: not-reached), the elapsed time monitoring unit **202** proceeds to step S**2203**, and if the "long elapsed period" has been reached (step S**2202**: reached), the elapsed time monitoring unit **202** proceeds to step S**2210**.

At step S**2203**, the elapsed time monitoring unit **202** refers to the mode in the optical wavelength path management information **210** (step S**2203**), and determines whether the mode is insertion (Add) (step S**2204**). If the mode is insertion (Add) (step S**2204**: YES), this is a mode for time monitoring and therefore, the elapsed time monitoring unit **202** proceeds to step S**2205**. If the mode is other than insertion (Add) (step S**2204**: NO), the elapsed time monitoring unit **202** proceeds to step S**2210**.

At step S**2205**, the elapsed time monitoring unit **202** increments the "elapsed period" in the optical wavelength path management information **210** (step S**2205**) and makes a comparison to determine whether the "elapsed time" in the optical wavelength path management information **210** is greater than the long-setup elapsed time (step S**2206**). If the "elapsed period" of the optical wavelength path management information **210** is greater (e.g., equal to or greater) than the long-setup elapsed time (step S**2207**: YES), the elapsed time monitoring unit **202** proceeds to step S**2208**. If the "elapsed period" is shorter (e.g., less) than the long-setup elapsed time (step S**2207**: NO), the elapsed time monitoring unit **202** proceeds to step S**2210**.

At step S**2208**, the elapsed time monitoring unit **202** sets the "long elapsed period" in the optical wavelength path management information **210** to "reached" (step S**2208**). The elapsed time monitoring unit **202** requests the optical wavelength path movement preparing unit **1902** to perform a movement process for the optical wavelength path (step S**2209**). Subsequently, at step S**2210**, the elapsed time monitoring unit **202** determines whether the process has been executed for all the registered optical wavelength paths and if so (step S**2210**: YES), the elapsed time monitoring unit **202** terminates the process and restarts the timer. On the other hand, if an unprocessed path exists (step S**2210**: NO), the elapsed time monitoring unit **202** returns to step S**2201**.

FIG. **23** is a flowchart of a process of determining whether an optical wavelength path can be moved according to the second embodiment. A process executed by the optical wavelength path movement preparing unit **1902** will be described. The optical wavelength path movement preparing unit **1902** of the NE **101** executes a process of determining whether a long-elapsed-period optical wavelength path is movable and for transmitting a request for movement to an adjacent NE

101 on the route of the optical wavelength path if movable, or suspending the movement if not movable.

The optical wavelength path movement preparing unit **1902** receives from the elapsed time monitoring unit **202**, a movement request for a long-elapsed-period optical wavelength path and executes the following process. First, the optical wavelength path movement preparing unit **1902** checks the optical wavelength path management information **210** for availability of a long-term-setting-path **100**A (step S**2301**). If available (step S**2302**: YES), the optical wavelength path movement preparing unit **1902** proceeds to step S**2303**, and if not available (step S**2302**: NO), the optical wavelength path movement preparing unit **1902** proceeds to step S**2306**.

At step S**2303**, the optical wavelength path movement preparing unit **1902** sets the available long-term-setting-path **100**A in the "waiting for vacancy" for the optical wavelength to be moved, in the optical wavelength path management information **210** (step S**2303**). The available long-term-setting-path **100**A is set as the movement destination optical wavelength in "the movement destination optical wavelength (λ)" of the message sent between NEs **101** related to the path movement request (step S**2304**). The optical wavelength path movement preparing unit **1902** requests the inter-NE message transmitting unit **1903** to perform a transmission process for the movement request message (step S**2305**) and waits for the next request.

At step S**2306**, since the optical wavelength path cannot be moved, the optical wavelength path movement preparing unit **1902** sets "suspended" in the "waiting for vacancy" for the optical wavelength to be moved, in the optical wavelength path management information **210** (step S**2306**) and waits for the next request.

FIG. **24** is a flowchart of a process of requesting optical wavelength path movement, by message reception from an adjacent NE according to the second embodiment. The process depicted in FIG. **24** is described as a process executed by the inter-NE message receiving unit **1904** of the NE **101**.

First, when the WDM monitoring control unit **1905** receives a request from an adjacent NE **101** through an OSC, the inter-NE message receiving unit **1904** determines the "message type" of the message between the NEs **101** (step S**2401**). If the received "message type" is "path movement" (step S**2401**: path movement), the inter-NE message receiving unit **1904** proceeds to step S**2402**, and if the received "message type" is "path block cancellation" (step S**2401**: path block cancellation), the inter-NE message receiving unit **1904** proceeds to step S**2408**.

At step S**2402**, the "detailed type" is determined and, in the case of "request" (step S**2402**: request), the inter-NE message receiving unit **1904** checks the mode in the optical wavelength path management information **210** corresponding to the movement source optical wavelength (λ) (step S**2403**). If the "detailed type" is "response" (step S**2402**: response), the inter-NE message receiving unit **1904** proceeds to step S**2407**.

After step S**2403**, the inter-NE message receiving unit **1904** determines whether the movement source optical wavelength (λ) is branch (Drop) (step S**2404**). If the movement source optical wavelength (λ) is branch (Drop) (step S**2404**: YES), the inter-NE message receiving unit **1904** proceeds to step S**2405**I; if other than branch (Drop) (step S**2404**: NO), the inter-NE message receiving unit **1904** proceeds to step S**2406**.

At step S**2405**, the inter-NE message receiving unit **1904** notifies the optical wavelength path moving unit **203** of the movement source optical wavelength (λ) and the movement destination optical wavelength (λ), as a movement request (step S**2405**). At step S**2406**, the inter-NE message receiving unit **1904** notifies the optical wavelength path movement preparing unit **1902** of the movement source optical wavelength (λ) and the movement destination optical wavelength (λ), as a movement request (step S**2406**). At step S**2407**, the inter-NE message receiving unit **1904** notifies the optical wavelength path moving unit **203** of the movement source optical wavelength (λ) and a determination result, as a movement response (step S**2407**). At step S**2408**, the inter-NE message receiving unit **1904** notifies the optical wavelength path movement preparing unit **1902** of a released optical wavelength (λ), as a path block cancellation (step S**2408**). After the operations at step S**2405** to step S**2408**, the inter-NE message receiving unit **1904** waits for the next process request.

FIG. **25** is a flowchart of a process of determining whether movement is possible at a given NE and transferring a movement request to another NE based on a request for optical wavelength path movement according to the second embodiment. The process depicted in FIG. **25** is executed by the optical wavelength path movement preparing unit **1902** and upon receiving a request for movement of the long-elapsed-period optical wavelength path from another NE **101**, the optical wavelength path movement preparing unit **1902** determines whether the optical wavelength path movement preparing unit **1902** can perform the movement (be performed by the NE **101** thereof). If the request can be accepted, the request is further transferred to another adjacent NE **101** on the route, and if the request cannot be accepted, a response of NG is returned to the NE **101** that issued the movement request.

Upon receiving a movement request from another NE **101** via the inter-NE message receiving unit **1904**, the optical wavelength path movement preparing unit **1902** first sets the "long elapsed period" in the optical wavelength path management information **210** to "reached" (step S**2501**). The optical wavelength path movement preparing unit **1902** refers to the optical wavelength path management information **210** to check whether an optical wavelength specified as the movement destination optical wavelength (λ) is already used as another optical wavelength path (step S**2502**). If the specified optical wavelength is not already used (step S**2503**: NO), the optical wavelength path movement preparing unit **1902** proceeds to step S**2504**, and if used (step S**2503**: YES), the optical wavelength path movement preparing unit **1902** proceeds to step S**2508**.

At step S**2504**, the optical wavelength path movement preparing unit **1902** sets the movement destination optical wavelength (λ) in the optical wavelength path management information **210** to the long-term-setting-path **100**A specified as the movement destination (step S**2504**). The optical wavelength path movement preparing unit **1902** then determines whether the "waiting for vacancy" indicates "waiting" (step S**2505**). If the "waiting for vacancy" indicates "waiting" (step S**2505**: YES), the "waiting for vacancy" in the optical wavelength path management information **210** is set to "none" (step S**2506**) and the process proceeds to step S**2507**. If the "waiting for vacancy" does not indicate "waiting" (step S**2505**: NO), the optical wavelength path movement preparing unit **1902** proceeds to step S**2507**.

At step S**2507**, the optical wavelength path movement preparing unit **1902** requests the inter-NE message transmitting unit **1903** to transfer the received movement request message to another NE **101** (step S**2507**) and waits for the next request.

At step S**2508**, the optical wavelength path movement preparing unit **1902** sets "waiting" in the "waiting for vacancy" in the optical wavelength path management information **210** (step S**2508**), then requests the inter-NE message transmitting unit **1903** to transmit a movement request response set to "NG" to another NE **101** (step S**2509**), and waits for the next request.

FIG. **26** is a flowchart of a movement process based on a request for optical wavelength path movement according to the second embodiment. In FIG. **26**, the optical wavelength path movement preparing unit **1902** determines whether a long-elapsed-period optical wavelength path is movable. The optical wavelength path movement preparing unit **1902** transmits a movement request to an adjacent NE **101** on the route of the optical wavelength path if movable, or suspends the movement if not movable.

When receiving a movement request from the inter-NE message receiving unit **1904**, the optical wavelength path movement preparing unit **1902** first sets the "long elapsed period" in the optical wavelength path management information **210** to "reached" (step S**2601**). The optical wavelength path movement preparing unit **1902** then checks whether the specified optical wavelength is registered as the movement destination in the optical wavelength path management information **210** (step S**2602**). If not registered (step S**2603**: NO), the optical wavelength path movement preparing unit **1902** proceeds to step S**2604**, and if registered (step S**2603**: YES), the optical wavelength path movement preparing unit **1902** proceeds to step S**2607**.

At step S**2604**, optical wavelength path movement preparing unit **1902** moves the optical wavelength path of the movement source specified by the movement request to the optical wavelength of the movement destination (step S**2604**). The optical wavelength path movement preparing unit **1902** sets information concerning the optical wavelength of the movement destination as the information of the optical wavelength in the optical wavelength path management information **210** (step S**2605**). The optical wavelength path movement preparing unit **1902** then requests the inter-NE message transmitting unit **1903** to transmit a message for a movement request response set to "OK" (step S**2606**) and waits for the next request.

At step S**2607**, the optical wavelength path movement preparing unit **1902** sets "waiting" in the "waiting for vacancy" of the optical wavelength path management information **210** (step S**2607**), then requests the inter-NE message transmitting unit **1903** to transmit a message for a movement request response set to "NG" (step S**2608**), and waits for the next request.

FIG. **27** is a flowchart of a process of determining optical wavelength movement based on reception of a movement response for an optical wavelength path. The process depicted in FIG. **27** is executed by the optical wavelength path moving unit **203**. The optical wavelength path moving unit **203** receives a movement response request for a long-elapsed-period optical wavelength path, determines whether the movement is possible, and moves the optical wavelength if possible. If it is determined that the movement is impossible, the optical wavelength path moving unit **203** returns "NG" as a response to the movement request transmission source NE **101**.

When receiving a request for a movement response from the inter-NE message receiving unit **1904**, the optical wavelength path moving unit **203** first determines a "response result" (step S**2701**). If the "response result" is "NG" (step S**2701**: NG), the optical wavelength path moving unit **203** proceeds to step S**2702**; if "OK" (step S**2701**: OK), the optical wavelength path moving unit **203** proceeds to step S**2711**.

At step S**2702**, the optical wavelength path moving unit **203** refers to the optical wavelength path route information to check the path setting in the optical wavelength path management information **210** (step S**2702**). If the type of the path setting is "insertion (Add)" (step S**2703**: Add), the optical wavelength path moving unit **203** proceeds to step S**2704**; if the type is "passage (Thru)" (step S**2703**: Thru), the optical wavelength path moving unit **203** proceeds to step S**2706**.

At step S**2704**, the optical wavelength path moving unit **203** checks whether an optical wavelength is available excluding denied long-term-setting-paths **100**A (step S**2704**). If an optical wavelength is available (step S**2705**: YES), the optical wavelength path moving unit **203** proceeds to step S**2708**. If not available (step S**2705**: NO), the optical wavelength path moving unit **203** proceeds to step S**2706**.

At step S**2706**, the optical wavelength path moving unit **203** sets the movement destination optical wavelength (λ) in the optical wavelength path management information **210** to "none (Non)" (step S**2706**), sets the movement object optical wavelength in the optical wavelength path management information **210** to "suspended" (step S**2707**), and proceeds to step S**2714**.

At step S**2708**, in the optical wavelength path management information **210**, the optical wavelength path moving unit **203** sets to the available long-term-setting-path **100**A, the optical wavelength that is to be moved (step S**2708**). The optical wavelength path moving unit **203** then sets the available long-term-setting-path **100**A as the movement destination optical wavelength in the movement request (step S**2709**). The optical wavelength path moving unit **203** requests the inter-NE message transmitting unit **1903** to transmit a message for a movement request (step S**2710**) and waits for the next message.

At step S**2711**, the optical wavelength path moving unit **203** changes the movement source optical wavelength specified by the movement response to the optical wavelength of the movement destination (step S**2711**). The optical wavelength path moving unit **203** copies the information of the optical wavelength in the optical wavelength path management information **210**, according to the information of the movement destination optical wavelength (λ). The optical wavelength path moving unit **203** sets the movement destination optical wavelength (λ) to "none (Non)" (step S**2712**). The optical wavelength path moving unit **203** determines the type of the path setting (step S**2713**); and if the type is "passage (Thru)" (step S**2713**: Thru) or if the type is "insertion (Add)" (step S**2713**: Add), the optical wavelength path moving unit **203** requests the inter-NE message transmitting unit **1903** to transfer the message for the movement response (step S**2714**) and waits for the next message reception.

FIG. **28** is a flowchart of a process associated with deletion of an optical wavelength set as a long-term-setting-path according to the second embodiment. FIG. **28** depicts a process executed by the suspended path moving unit **204**. When the optical wavelength path set to an optical wavelength of the long-term-setting-path **100**A is deleted, the suspended path moving unit **204** makes a notification of the deletion of the optical wavelength path so as to move the long-elapsed-period optical wavelength path waiting for movement in another NE **101**. If the optical wavelength path of the long-term-setting-path **100**A is deleted at an NE **101** for insertion (Add), the movement request for the long-elapsed-period optical wavelength path is immediately made through a message between the NEs **101**.

When receiving the notification of the optical wavelength path release from the optical wavelength path setting unit **201**, the suspended path moving unit **204** first checks whether the optical wavelength specified to be deleted by a maintenance person is the long-term-setting-path **100**A (step S**2801**). If the long-term-setting-path **100**A is to be deleted (step S**2802**: YES), the suspended path moving unit **204** proceeds to step S**2803**; if the long-term-setting-path **100**A is not to be deleted (step S**2802**: NO), the suspended path moving unit **204** terminates the process and waits for the next notification.

At step S**2803**, the suspended path moving unit **204** checks the waiting for vacancy in the optical wavelength path management information **210** (step S**2803**). If the waiting for vacancy indicates "waiting (suspended)" (step S**2804**: YES), the process proceeds to step S**2805**. If the waiting for vacancy indicates "none" (step S**2804**: NO), the suspended path moving unit **204** terminates the process and waits for the next notification.

At step S**2805**, the suspended path moving unit **204** refers to the optical wavelength path route information to check the type of the path setting (step S**2805**). If the path setting is "insertion (Add)" (step S**2805**: Add), the suspended path moving unit **204** proceeds to step S**2806**. If the path setting is "passage (Thru) or branch (Drop)" (step S**2805**: Thru or Drop), the suspended path moving unit **204** proceeds to step S**2810**.

At step S**2806**, the suspended path moving unit **204** sets the released optical wavelength (λ) specified in a path block cancellation notification, as the movement destination optical wavelength (λ) in the optical wavelength path management information **210** (step S**2806**). Subsequently, the suspended path moving unit **204** sets the waiting for vacancy in the optical wavelength path management information **210** to "none" (step S**2807**) and sets the released optical wavelength (λ) specified in the path block cancellation notification, as the movement destination optical wavelength (λ) in an inter-NE message for the path movement request (step S**2808**). The suspended path moving unit **204** requests the inter-NE message transmitting unit **1903** to transmit the message of the movement request (step S**2809**), terminates the process, and waits for the next notification.

At step S**2810**, the suspended path moving unit **204** requests the inter-NE message transmitting unit **1903** to transmit a message of a path block cancellation notification (step S**2810**), terminates the process, and waits for the next notification.

FIG. **29** is a flowchart of a process of resuming movement of an optical wavelength path based on notification of path block cancellation according to the second embodiment. The process of FIG. **29** is executed by the optical wavelength path movement preparing unit **1902**. When receiving the inter-NE message of the path block cancellation supplied from another NE **101**, the optical wavelength path movement preparing unit **1902** resumes the movement of the long-elapsed-period optical wavelength path. If the NE **101** of the optical wavelength path movement preparing unit **1902** is a passage (Thru) NE, a process is executed only for transferring the inter-NE message of the path block cancellation.

When receiving a request for the path block cancellation from the inter-NE message receiving unit **1904**, the optical wavelength path movement preparing unit **1902** first checks the "waiting for vacancy" in the optical wavelength path management information **210** (step S**2901**). If the waiting for vacancy indicates "waiting (suspended)" (step S**2902**: YES), the optical wavelength path movement preparing unit **1902** proceeds to step S**2903**. If the waiting for vacancy indicates "none", the optical wavelength path movement preparing unit **1902** terminates the process and waits for the next request.

At step S**2903**, the optical wavelength path movement preparing unit **1902** checks the type of the path setting from the optical wavelength path route information (step S**2903**). If the type of the path setting is "insertion (Add)" (step S**2903**: Add), the optical wavelength path movement preparing unit **1902** proceeds to step S**2904**. If the type of the path setting is "passage (Thru)" (step S**2903**: Thru), the optical wavelength path movement preparing unit **1902** proceeds to step S**2908**.

At step S**2904**, the optical wavelength path movement preparing unit **1902** requests the inter-NE message transmitting unit **1903** to transfer the message of the path block cancellation notification (step S**2904**). Subsequently, the optical wavelength path movement preparing unit **1902** sets the "waiting for vacancy" in the optical wavelength path management information **210** to "none" (step S**2905**). The optical wavelength path movement preparing unit **1902** sets the released optical wavelength (λ) notified by the path block cancellation as the movement destination optical wavelength (λ) in an inter-NE message for the path movement request (step S**2906**) and the optical wavelength path movement preparing unit **1902** requests the inter-NE message transmitting unit **1903** to transmit the message for the movement request (step S**2907**), terminates the process, and waits for the next request.

At step S**2908**, the optical wavelength path movement preparing unit **1902** sets the released optical wavelength (λ) notified by the path block cancellation, as the movement destination optical wavelength (λ) having "waiting (suspend)" in the "waiting for vacancy" in the optical wavelength path management information **210** (step S**2908**), terminates the process, and waits for the next request.

FIG. **30** is a sequence diagram of optical wavelength path movement through message transmission/reception between the NEs according to the second embodiment. If a long-period optical wavelength path is determined in the insertion (Add) NE **101** of the optical wavelength path to be moved, a movement request is transmitted to the NEs **101** on the route of the optical wavelength path. The NEs **101** on the route accept the movement request if an optical wavelength specified as the movement destination is available, and sequentially move the optical wavelength path.

As depicted in FIG. **30**, if a given optical wavelength path is determined as the long-period optical wavelength path at the NE 1 (**101**) (step S**3001**), the optical wavelength of the movement destination is reserved (step S**3002**) and the movement request **2101** depicted in FIG. **21** is transmitted to the adjacent NE #2 (**101**) on the route of the optical wavelength path (step S**3003**).

The NE #2 (**101**) receiving the movement request **2101** reserves the optical wavelength of the movement destination (step S**3004**) and transmits the movement request **2101** to the adjacent NE #3 (**101**) on the route of the optical wavelength path (step S**3005**).

The NE #3 (**101**) receiving the movement request **2101** moves the optical wavelength according to the movement request (step S**3006**) and transmits a movement result "OK/NG" to the adjacent NE #2 (**101**) (step S**3007**). The NE #2 (**101**) also moves the optical wavelength according to the movement request (step S**3008**) and transmits a movement result "OK/NG" to the adjacent NE #1 (**101**) (step S**3009**). In the example of FIG. **30**, both NEs can move the optical wavelength and return "OK". The NE #1 (**101**) also moves the optical wavelength according to the movement request (step S**3010**). As described above, the movement request message is exchanged between the NEs **101**, and the NEs **101** move the optical wavelength path in a synchronized manner.

FIG. **31** is a diagram of a state in which a predetermined optical wavelength path is moved according to the second embodiment. As depicted in FIG. **31**, when the optical wavelength path of the optical wavelength λ4 (terminated by the NEs #1 and #3; the NE #2 is Thru) becomes a long-elapsed-period optical wavelength path and the optical wavelength λ3 among the long-term-setting-paths **100**A is available, the optical wavelength path is moved by changing the optical wavelength from λ4 to λ3.

FIGS. **32**A, **32**B, and **32**C are charts of settings in the optical wavelength path management information at the time of movement of the optical wavelength path according to the second embodiment. FIGS. **32**A, **32**B, and **32**C depict settings in the optical wavelength path management information at the time of movement of the optical wavelength path depicted in FIG. **31**. FIG. **32**A depicts the optical wavelength path management information **210** at the time of start of movement of the optical wavelength path for optimization; FIG. **32**B depicts the optical wavelength path management information **210** at the time of a request for the movement of the optical wavelength path for optimization; and FIG. **32**C depicts the optical wavelength path management information **210** at the time of completion of the movement.

As depicted in FIG. **32**A, at the start of movement for optimization, since the elapsed time of the optical wavelength path of the optical wavelength λ4 set to the path setting mode of insertion (Add) has reached a threshold value ("10 hours" in the example of FIG. **32**A) for the long elapsed time at the elapsed time monitoring unit **202**, the NE #1 (**101**) determines that the optical wavelength path is the long-setup optical wavelength path and sets a long elapsed period **3201** in the optical wavelength path management information to "reached".

The optical wavelength path movement preparing unit **1902** searches for an available long-term-setting-path (λ1 to λ3), determines that the optical wavelength λ3 is available and therefore, sets and reserves the movement destination optical wavelength λ3 (**3202** in FIG. **32**A) as a reserved path for the optical wavelength λ4 in the optical wavelength path management information.

As depicted in FIG. **32**B, at the time of a request for the movement for optimization, the optical wavelength path movement preparing unit **1902** of the NE #1 (**101**) transmits the movement request **2101** from the inter-NE message transmitting unit **1903** by utilizing the OSC, to the adjacent NE #2 (directional path #1) **101** toward the branch (Drop) NE #3 (**101**) of the optical wavelength path to be moved.

The inter-NE message receiving unit **1904** of the NE #2 (**101**) receives the movement request **2101** from the NE #1 (**101**) through the directional path #1. The optical wavelength path movement preparing unit **1902** checks whether the optical wavelength λ3 set as the movement destination optical wavelength λ of the movement request **2101** is available in the directional path #1. If it is determined that the corresponding optical wavelength λ3 (**3211** in FIG. **32**B) is available, the optical wavelength λ3 of the movement destination is set and reserved as the movement destination λ of the optical wavelength λ4 of the directional path #1 in the optical wavelength path management information **210**.

Since the optical wavelength λ4 is in a mode for passage (Thru) at the NE #2 (**101**), it is also checked whether the optical wavelength λ3 specified as the movement destination λ by the movement request is available in the directional path #2 of the NE #2 (**101**). Since it can be determined that the optical wavelength λ3 is available, the movement request **2101** is transferred to the adjacent NE #3 (directional path #2) **101** toward the branch (Drop) NE (NE #3) **101**.

At the NE #3 (**101**), the inter-NE message receiving unit **1904** receives the movement request **2101** from the NE #1 (**101**) through the directional path #1. The optical wavelength path moving unit **203** checks whether the optical wavelength λ4 of the movement source set in the movement request **2101** is available. Since it can be determined that the optical wavelength λ4 is available, the location of the optical wavelength set to λ4 in the optical wavelength path management information **210** is set to λ3, which has been specified as the movement destination λ of the movement request **2101**. Since the optical wavelength path is branched (dropped) at the NE #3 (**101**), the NE #3 (**101**) changes λ4 of the movement source specified in the request to λ3 (**3212** in FIG. **32**B).

As depicted in FIG. **32**C, at the time of completion of the movement for optimization, the NE #3 (**101**) sets "OK" to respond that the movement request **2101** from the directional path #1 is accepted. When receiving the response to the movement request **2101** from the directional path #2, the NE #2 (**101**) moves the optical wavelength λ4 to the reserved optical wavelength λ3 (**3221** in FIG. **32**C). The NE #1 (**101**) receives the response to the movement request **2101** from the directional path #1 and moves the optical wavelength path of the optical wavelength λ4 to the reserved optical wavelength λ3 (**3222** in FIG. **32**C).

FIG. **33** is a sequence diagram of movement after suspension of an optical wavelength path according to the second embodiment. FIG. **33** depicts a state of suspension of movement of an optical wavelength when the NEs #1 to #3 (**101**) on the route of the optical wavelength path have no available optical wavelength as the movement destination specified by the movement request **2101** and cannot accept the movement request **2101**.

The NE #1 (**101**) determines a long-elapsed-period optical wavelength path (step S**3301**). However, if a movement destination for the long-elapsed-period optical wavelength path is not available, the movement of the optical wavelength is suspended, and the optical wavelength (the movement destination) is reserved (step S**3302**).

The NE #1 (**101**) subsequently sends the movement request **2101** to the adjacent NE #2 (**101**) (step S**3303**). If the optical wavelength (the movement destination) is not available at the NE #2 (**101**) (step S**3304**), "NG" is returned as the movement response **2101** to the NE #1 (**101**) (step S**3305**).

As a result, the NE #1 (**101**) cancels the reservation of the optical wavelength (the movement destination) (step S**3306**) and suspends the movement of the movement source optical wavelength (step S**3307**). If a long-term-setting-path **100**A becomes available at the NE #2 (**101**) (step S**3308**), the NE #2 (**101**) sends a path block cancellation to the NE #1 (**101**) (step S**3309**).

The NE #1 (**101**) reserves, as the movement destination, the optical wavelength indicated in the block cancellation (step S**3310**). The NE #1 (**101**) sends the movement request **2101** to the NE #2 (**101**) (step S**3311**). The NE #2 (**101**) reserves the optical wavelength (the movement destination) (step S**3312**) and sends the movement request **2101** to the adjacent NE #3 (**101**) (step S**3313**).

The NE #3 (**101**) performs movement to the optical wavelength specified by the movement request (step S**3314**) and sends "OK" as the movement response **2101** to the NE #2 (**101**) (step S**3315**). The NE #2 (**101**) performs movement to the optical wavelength specified by the movement request (step S**3316**) and sends "OK" as the movement response **2101** to the NE #1 (**101**) (step S**3317**). The NE #1 (**101**) performs movement to the optical wavelength specified by the movement request **2101** (step S**3318**).

As described above, if the long-term-setting-path **100**A is not available, the movement of the optical wavelength is suspended and, when the long-term-setting-path **100**A becomes available, the suspension can be cancelled to move the optical wavelength. The suspension, the suspension cancellation and the movement can be performed through communication between the NEs #1 to #3 (**101**) in synchronization with one another.

FIG. **34** is a diagram of a state of movement after movement suspension of the optical wavelength path according to the second embodiment. As depicted in FIG. **34**, it is assumed that all the wavelengths λ1 to λ3 among the long-term-setting-paths **100**A are being used and are unavailable. In this case, even when the optical wavelength path (terminated by the NEs #1 and #3; the NE #2 is Thru) of the optical wavelength λ4 becomes a long-elapsed-period optical wavelength path, movement to a long-term-setting-path **100**A cannot be performed and the movement is suspended.

It is assumed that a vacancy subsequently occurs because the optical wavelength path (terminated by the NEs #2 and #3) **100***d* of the optical wavelength λ3 among the long-term-setting-paths **100**A has been deleted. As a result, the suspended optical wavelength path of the optical wavelength λ4 can be moved to the optical wavelength λ3.

FIGS. **35**AA, **35**AB, **35**AC, **35**BD, **35**BE, and **35**BF are charts of setting details in the optical wavelength path management information including suspension of the optical wavelength path according to the second embodiment. FIGS. **35**AA to **35**AC depict the setting details of the optical wavelength path management information from the suspension to the movement completion of the optical wavelength path depicted in FIG. **34**. FIG. **35**AA depicts the optical wavelength path management information **210** at the start of suspension of the movement of the optical wavelength path for optimization; FIG. **35**AB depicts the optical wavelength path management information **210** at the time of suspension completion of the movement of the optical wavelength path for optimization; and FIG. **35**AC depicts the optical wavelength path management information **210** at the start of suspension cancellation of the movement of the optical wavelength path for optimization. FIG. **35**BD depicts the optical wavelength path management information **210** at the time of request for suspension cancellation of the movement of the optical wavelength path for optimization; FIG. **35**BE depicts the optical wavelength path management information **210** at the time of completion of suspension cancellation of the movement of the optical wavelength path for optimization; and FIG. **35**BF depicts the optical wavelength path management information **210** at the time of completion of the movement.

As depicted in FIG. **35**AA, at the start of suspension of the movement for optimization, the elapsed time monitoring unit **202** of the NE #1 (**101**) determines that the optical wavelength path of the optical wavelength λ4 is the long-setting optical wavelength path because of the elapse of 10 hours and sets a long elapsed period **3501** to "reached". An available long-term-setting-path (λ1 to λ3) of the NE #1 (**101**) is searched for and since it is determined that the optical wavelength λ3 is available, the optical wavelength λ3 is set and reserved as the movement destination λ (**3502** in FIG. **35**AA) of λ4 of the optical wavelength path management information **210**. The NE #1 (**101**) transmits the movement request **2101** from the inter-NE message transmitting unit **1903** to the adjacent NE (directional path #1) toward the branch (Drop) NE #3 (**101**) of the optical wavelength path.

The inter-NE message receiving unit **1904** of the NE #2 (**101**) receives the movement request from the directional path #1. The optical wavelength path movement preparing unit **1902** checks whether the optical wavelength λ3 set as the movement destination λ of the movement request **2101** is available. Since it is determined that the optical wavelength is available, the optical wavelength λ3 of the movement destination λ (**3503** in FIG. **35**AA) is set and reserved as a reserved path of the optical wavelength λ4 of the optical wavelength path management information. Since the mode of the NE #2 (**101**) is the through-setting, the process of the directional path #2 is also executed according to the movement request **2101** from the directional path #1.

As depicted in FIG. **35**AB, at the time of suspension completion of the movement for optimization, the optical wavelength path movement preparing unit **1902** of the NE #2 (**101**) checks whether the optical wavelength λ3 specified in the movement request **2101** is available in the directional path #2. Since it is determined that the optical wavelength is not available, waiting for vacancy **3504** for the optical wavelength λ4 in the optical wavelength path management information **210** is set to "waiting". The movement destination λ (**3505** in FIG. **35**AB) of the directional path #1 set in response to the movement request **2101** from the insertion (Add) NE #1 (**101**) is set to "Non (no movement destination)". To notify the NE on the route to the insertion (Add) NE #1 (**101**) that the movement is blocked, the inter-NE message transmitting unit **1903** is requested to transmit the movement response **2101** set to "NG" to the adjacent NE #1 (**101**) on the directional path #1 side.

When the inter-NE message receiving unit **1904** of the NE #1 (**101**) receives "NG" as the movement response **2101**, the optical wavelength path moving unit **203** sets the movement destination λ (**3506** in FIG. **35**AB) of the optical wavelength path management information **210** to "Non (no movement destination)" and sets waiting for vacancy **3507** to "waiting".

As depicted in FIG. **35**AC, at the start of suspension cancellation of the movement for optimization, since the insertion (Add) path of the optical wavelength λ3 of the directional path #2 is deleted, the optical wavelength path setting unit **201** notifies the suspended path moving unit **204** of the deletion. The suspended path moving unit **204** determines that the deleted optical wavelength λ3 is included among the long-term-setting-paths **100**A. Therefore, an optical wavelength having the waiting for vacancy set to "waiting" is checked for among the long-elapsed-period optical wavelength paths. Since the optical wavelength λ4 has waiting for vacancy **3508** set to "waiting", the inter-NE message transmitting unit **1903** is requested to transmit a notification of the path block cancellation.

As depicted in FIG. **35**BD, at the time of request for suspension cancellation of the movement for optimization, the optical wavelength path movement preparing unit **1902** of the NE **101** confirms that the optical wavelength λ3 is deleted from the received notification of the path block cancellation and resumes the movement of the optical wavelength λ4 in the "waiting" state of the waiting for vacancy. The movement destination λ (**3510** of FIG. **35**BD) of the optical wavelength path management information **210** is set to the optical wavelength λ3 to reserve the movement destination. Waiting for vacancy **3511** is set to "none" to cancel the suspension. The NE #1 (**101**) requests the inter-NE message transmitting unit **1903** to transmit the movement request **2101** toward the branch (Drop) NE #3 (**101**) of the optical wavelength path.

As depicted in FIG. **35**BE, at the time of completion of suspension cancellation of the movement for optimization, the inter-NE message receiving unit **1904** of the NE #2 (**101**) receives the movement request **2101** from the NE #1 (**101**) through the directional path #1. The optical wavelength path movement preparing unit **1902** checks whether the optical wavelength (λ3) set as the movement destination λ in the movement request **2101** is available in the directional path #1. Since it is determined that the optical wavelength is available, the optical wavelength λ3 is set and reserved as the movement destination λ (**3512** of FIG. **35**BE) of the optical wavelength λ4 of the directional path #1 in the optical wavelength path management information **210**. Waiting for vacancy **3513** indicates "waiting" and therefore, is set to "none". Since the mode of the optical wavelength λ4 of the NE #2 (**101**) is the passage (Thru) setting, it is also checked whether the optical wavelength λ3 specified as the movement destination λ of the movement request **2101** is available in the directional path #2 of the NE #2 (**101**). Since it is determined that the optical wavelength is available, the optical wavelength λ3 is set as the movement destination λ (**3512**) and the waiting for vacancy **3513** is set to "none". The movement request **2101** is transferred to the directional path #2 of the adjacent NE #3 (**101**) toward the branch (Drop) NE #3 (**101**).

As depicted in FIG. **35**BF, at the time of completion of the movement for optimization, the inter-NE message receiving unit **1904** of the NE #3 (**101**) receives the movement request from the NE #1 (**101**). Since a mode **3514** of the specified movement source λ is a branch (Drop) path, the optical wavelength path moving unit **203** checks whether the optical wavelength λ4 of the movement source set in the movement request **2101** is available. Since it is determined that the optical wavelength is available, the location of the optical wavelength set to λ4 in the optical wavelength path management information **210** is set to the optical wavelength λ3 specified as the movement destination λ of the movement request **2101**. Since the optical wavelength path is branched (dropped) at the NE #3 (**101**), the NE #3 (**101**) changes the optical wavelength **3514** of the movement source specified in the movement request **2101** from λ4 to λ3.

The NE #3 (**101**) sets "OK" to transmit the acceptance of the movement request **2101** from the directional path #1 as the movement response **2101** to the NE #2 (**101**). The NE #2 (**101**) receives the movement response **2101** from the directional path #2 to move the optical wavelength λ4 to the reserved optical wavelength λ3. The NE #1 (**101**) receives the movement request **2101** from the directional path #1 to move the optical wavelength λ4 to the reserved optical wavelength λ3.

According to the second embodiment described above, based on the elapsed time of the optical wavelength path, the optical transmission apparatuses **101** on the transmission path performs the optical wavelength movement of a long-elapsed-period optical wavelength path having the prolonged elapsed time to the long-term-setting-path **100**A among the predetermined optical wavelength range, in synchronization with the other optical transmission apparatuses **101**. Even if the long-elapsed-period optical wavelength path having the prolonged elapsed time cannot be moved immediately, the movement suspended state is maintained and the movement can be performed as soon as a corresponding optical wavelength becomes available. As a result, the optical transmission apparatuses **101** can mutually manage and bring together in the predetermined long-term-setting-paths **100**A, the long-elapsed-period optical wavelength paths used for a long period to thereby prevent dispersion and thus, eliminate the fragmentation of the unused areas of the optical wavelength paths in WDM transmission that uses multiple wavelengths. The second embodiment can eliminate, in terms of eliminating fragmentation, the need for the control by the OpS **401**, which centrally manages the network.

According to the embodiments described above, based on the elapsed time after the optical wavelength path is set, long-elapsed-period optical wavelength paths having a long optical wavelength path setup period and subjects of the optimization are gather together in the predetermined long-term-setting-paths to prevent a scattering of the wavelengths. As a result, optical wavelengths capable of supporting short-period optical wavelength paths can be increased to ensure a larger settable number of the short-period optical wavelength paths and to increase the usage efficiency of the optical wavelengths of the WDM transmission. A long-distance optical wavelength path (long path) can easily be set. Since the long-elapsed-period optical wavelength paths are preferentially assigned to the predetermined long-term-setting-paths, the number of times that optical wavelengths are moved to optimize fragmentation can be reduced and the interruption of communication service can be suppressed to improve the quality of the communication signals.

The optical wavelength path rearranging method described in the present embodiment may be implemented by executing a prepared program on a computer such as a personal computer and a workstation. The program is stored on a non-transitory, computer-readable recording medium such as a hard disk, a flexible disk, a CD-ROM, an MO, and a DVD, read out from the computer-readable medium, and executed by the computer. The program may be distributed through a network such as the Internet.

According to an embodiment, the optical wavelength path to be rearranged can be properly determined and the fragmentation can be eliminated efficiently.

All examples and conditional language provided herein are intended for pedagogical purposes of aiding the reader in understanding the invention and the concepts contributed by the inventor to further the art, and are not to be construed as limitations to such specifically recited examples and conditions, nor does the organization of such examples in the specification relate to a showing of the superiority and inferiority of the invention. Although one or more embodiments of the present invention have been described in detail, it should be understood that the various changes, substitutions, and alterations could be made hereto without departing from the spirit and scope of the invention.

What is claimed is:

1. An optical wavelength path rearranging method comprising:

setting an optical wavelength path to a newly-set-path optical wavelength range in an optical wavelength division multiplexing network;

detecting time that elapses since the setting of the optical wavelength path; and

moving to a predetermined long-period optical wavelength range different from the newly-set-path optical wavelength range, the optical wavelength path for which the detected elapsed time is longer than a predetermined constant period, wherein

the optical wavelength path rearranging method is executed by a processor.

2. The optical wavelength path rearranging method according to claim **1**, further comprising

suspending movement of the optical wavelength path, when the optical wavelength path cannot be moved to the predetermined long-period optical wavelength range, wherein

the moving includes moving the optical wavelength path to the long-period optical wavelength range, according to an occurrence of a vacancy of a movement destination optical wavelength within the long-period optical wavelength range.

3. The optical wavelength path rearranging method according to claim **1**, further comprising

comparing information concerning an optical wavelength of the optical wavelength path and a transmission section of the optical wavelength path against information concerning an available optical wavelength within the long-period optical wavelength range and the transmission section, wherein

the moving includes moving the optical wavelength path to the available optical wavelength and the transmission section capable of accommodation.

4. A non-transitory, computer-readable recording medium that stores an optical wavelength path rearranging program that causes a computer to execute a process comprising:

setting an optical wavelength path to a newly-set-path optical wavelength range in an optical wavelength division multiplexing network;

detecting time that elapses since the setting of the optical wavelength path; and

moving to a predetermined long-period optical wavelength range different from the newly-set-path optical wavelength range, the optical wavelength path for which the detected elapsed time is longer than a predetermined constant period.

5. The recording medium according to claim **4**, further comprising

suspending movement of the optical wavelength path, when the optical wavelength path cannot be moved to the predetermined long-period optical wavelength range, wherein

the moving includes moving the optical wavelength path to the long-period optical wavelength range, according to an occurrence of a vacancy of a movement destination optical wavelength within the long-period optical wavelength range.

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